Attachment A2 - Effects of Releases of Contaminant During Dredging

Modeling analyses were conducted to evaluate the effect of sediment and contaminants released during dredging to support the selection of monitoring locations that will provide data for comparison to the Resuspension Performance Standard. These analyses were performed with the models that had been used in the evaluation of alternatives to support the development of the ROD. Linked modeling components used in the evaluation of alternatives leading up to the ROD included hydrodynamic, sediment transport, organic carbon production and transport, and contaminant fate and transport models. Alternatives evaluated in support of the ROD included a No-Action alternative and three alternatives with active remediation, from which the alternative “Capping with Dredging for Flooding and Navigation” was selected and incorporated in the ROD. Details of these remedial alternatives (e.g. dredging and capping sequence and schedule, production rates, etc.) are presented in Appendix V (Responsiveness Summary) of the ROD (EPA, March 2016).

The simulations performed for the active remedial alternatives involved running the model from 2013 (end of the calibration period) to July 2020 when construction was assumed to begin, then through the period of construction (December 2025 for the selected remedy) and for a period of 30 years after completion of construction. The hydrographs and tidal boundary conditions used for the alternatives were developed by repeating the model inputs (boundary inflows and tides) for the period October 1995 – October 2010 (water years 1996-2010) in 15-year cycles and appending them to the historical water year 1995 – 2013 inputs to generate one continuous simulation for the period of water years 1996 through 2064. The No-Action alternative is identical to the active remedial alternatives up to July 2020, and uses the same hydrographs and tidal boundary conditions as the active alternatives, but does not include any remediation during the period of construction for the three active remedial alternatives. The No-Action alternative also does not include any dredging to reestablish the navigation channel in the LPR. Results from the No-Action alternative are used for comparison to results from the Selected Remedy, as described below.

The analyses described in this Attachment were performed to evaluate the effect of sediment and contaminants released during dredging, with the objective of assessing what might be observed in results of monitoring upstream and downstream of dredging operations, which will provide a basis for assessing whether conditions during the actual construction are consistent with expected releases during dredging and identify time periods when corrective actions may be needed to bring construction performance back into the range of acceptable conditions.

As sediment is released to the water column during dredging, carbon and contaminants associated with the sediment are also released. Model simulations of the remedial alternatives for the Lower 8-miles of the LPR assumed 3 percent of the mass of sediment, organic carbon and contaminants removed by dredging is released to the water column, with 1.5 percent released in the bottom layer and 1.5 percent released in the surface layer of the water column. In addition to comparing results of the Selected

Remedy and No-Action simulations to assess the fate of sediment and contaminants released during dredging, simulations were also run with additional variables added to the code to numerically tag sediment and contaminants released during dredging. This was accomplished by creating a parallel set of variables to track only the sediment or contaminants released during dredging, while sediment and contaminants from all other sources (i.e. boundary inputs and resuspension of native sediment) were simulated in the standard variable used to calculate concentrations of each size class (for sediment) and contaminant in every grid cell in the water column and bed each time step through the simulation. Total sediment and contaminant concentrations are obtained by adding the concentrations in the original and new tagging variables. The results of this assessment are intended to inform monitoring requirements at "near-field" and "far-field" locations.

The model simulation of the remedy includes dredging in 235 model grid cells, with a sequence and schedule developed and refined as part of the preparation of the Proposed Plan and the subsequent Responsiveness Summary. Results for representative locations, spaced at approximately two mile intervals throughout the Lower 8.3 miles, are presented as temporal plots of water column surface layer contaminants. The time periods presented for a given grid cell coincide with the time when dredging is simulated at that location (see Figure 1 for a map summarizing the dredging schedule). On each page, the top panel shows the flow at Dundee Dam on the left y-axis (shaded area) and the water surface elevation in the cell being dredged on the right axis (green line). The hydrographs and tidal boundary conditions used for the alternatives were constructed by repeating the model forcing for the period October 1995 – October 2010 (water years 1996-2010) in 15-year cycles. The remaining three panels from top to bottom present computed hourly average contaminant concentrations (or fractions of contaminant concentrations from dredging releases) in three adjacent model grid cells from upstream to downstream, respectively, with the river-mile of the grid cell indicated on the right side of each panel. It is noted that in some cases, dredging may proceed to a grid cell adjacent to one of the three cells shown for a specific location. The schedule of dredging begins concurrently on July 1, 2020, at three locations (two near RM 8.3 and a third near RM 2.6)-and progresses in the downstream direction from each starting point, ending in December 2025 (Figure 1). It is assumed that at each dredging location, 3 percent of the dredged sediments are released into the water column. A portion of this material is then transported across the upstream and downstream boundaries of the study area (RM 8.3 and RM 0, respectively).

2,3,7,8-TCDD

River Mile 8.1

Figure 2 presents surface layer 2,3,7,8-TCDD (also referred to as dioxin) concentrations for a 77 day period beginning on July 22, 2020 from the No-Action (blue line) and Selected Remedy (red line) model simulations. From top to bottom, the three 2,3,7,8-TCDD concentration time series panels present results for contiguous grid cells at RMs 8.2, 8.1, and 8.0, respectively. The pale brown shading in each panel indicates the time when dredging is simulated in that grid cell.

The differences between the 2,3,7,8-TCDD concentrations from the No Action and Selected Remedy simulations are similar in all three cells, which are dredged consecutively starting with the most upstream cell. During the dredging period the average 2,3,7,8-TCDD concentration from the No Action simulation is about 17 pg/L. The average concentration from the Selected Remedy simulation is about 70 pg/L. It is noted that dredging was simulated in the grid cells to the west of the three shown on Figure 2 in the preceding month, so the dioxin concentrations from the Selected Remedy are over 5 times greater than the No-Action concentrations even before the dredging starts at RM 8.1. Once the dredging operation at RM 8.1 begins, the dioxin concentration from the Selected Remedy simulation decreases slightly but primarily due to the transition from neap to spring tide. On average the 2,3,7,8-TCDD concentrations from the Selected Remedy remain about 3 times higher for the rest of the 77-day shown period as compared to the concentrations from the No Action simulation.

Results from the Selected Remedy simulation in which surface concentrations of 2,3,7,8-TCDD released during dredging are computed in a state variable separate from 2,3,7,8-TCDD concentrations from all other sources are shown on Figure 3 for the same time period as in Figure 2. The fraction of 2,3,7,8-TCDD originating from dredging releases (purple line; right y-axis) fluctuates between approximately 65 percent and 90 percent. As the total dioxin concentrations decrease with decreasing tidal amplitude, the fractions from dredging releases go up slightly.

The 2,3,7,8-TCDD concentrations shown on Figures 2 and 3 are from the surface layer of the water column. Figure 4 shows 2,3,7,8-TCDD concentrations for the bottom layer of the water column for the same time period as shown on Figures 2 and 3. 2,3,7,8-TCDD concentrations in the bottom layer follow the same general pattern, with slightly higher total concentrations. Percentages of 2,3,7,8-TCDD originating from dredging in both the surface and bottom layers are shown on Figure 5 for the same 77-day time period. The percentages of 2,3,7,8-TCDD originating from dredging are almost the same in the bottom and surface layers.

As an initial screening of what might be observed if 2,3,7,8-TCDD sampling was carried out upstream and downstream of the dredging operation, 2,3,7,8-TCDD concentrations in the grid cell upstream of the dredging location were subtracted from the 2,3,7,8-TCDD concentrations in the grid cell downstream (matched in time at hourly intervals). Although not presented graphically, statistical evaluations of the differences indicate that when dredging is simulated at RM 8.1, on average downstream concentrations are higher than upstream by 2.3 pg/L and 0.17 pg/L in the surface and bottom layers, respectively. In the surface layer downstream concentration is greater than upstream concentration by at least 6.2 pg/L 10 percent of the time and downstream is lower than upstream by at least 2.0 pg/L 10 percent of the time. In the bottom layer downstream concentration is greater than upstream concentration by at least 10 pg/L 10 percent of the time and downstream is lower than upstream by at least 8.3 pg/L 10 percent of the time. Because of redistribution of contaminants due to tidal circulation, the differences between upstream and downstream are not a good indicator of the fraction of 2,3,7,8-TCDD contributed by dredging.

River Mile 6.3

Figure 6 shows the 2,3,7,8-TCDD surface concentrations from the No Action and Selected Remedy runs at three contiguous grid cells at RMs 6.5, 6.3, and 6.1. At this location dredging is simulated near the beginning of year 2022 when river flows are closer to the annual average (Figures 2 – 5 showed results for July through October 2020). The three cells presented on Figure 6 are also dredged consecutively starting with the most upstream one. During the period of active dredging at RM 6.3, the average 2,3,7,8-TCDD concentration from the No Action simulation is approximately 4 pg/L, which is about a factor of three lower than the results near RM 8.1. Similarly, the average concentration from the Selected Remedy is about 24 pg/L, which is also about a factor of three lower than the results from RM 8.1. Comparisons of water column concentrations computed at RM 6.3 and RM 8.1 highlight both temporal variations related to hydrodynamic conditions and the effect of grid-scale spatial variations in contaminant concentrations.

The surface and bottom layer 2,3,7,8-TCDD concentrations originating from dredging releases during the same 77-day period are shown on Figures 7 and 8, respectively. The percent of 2,3,7,8-TCDD from dredging releases peaks at nearly 100 percent during the active dredging operation in the most upstream cell of the three shown. The peak fraction of dioxin attributed to the dredging releases is higher near RM 6.3 than RM 8.1 (results presented previously) because of the lower 2,3,7,8-TCDD concentrations from all other sources combined with relatively high 2,3,7,8-TCDD concentrations in the dredged material at RM 6.5. However, right after the dredging operation is completed at RM 6.3, the fraction of 2,3,7,8-TCDD from dredging releases starts to drop and on average remains at about 60 percent until the end of the 77-day period as compared to about 80 percent at RM 8.1.

Figure 9 compares the fractions of 2,3,7,8-TCDD due to dredging releases in the surface and bottom layers. Similar to the results near RM 8.1, the fractions in the surface and bottom layers are almost the same except right after the dredging operation is completed. For about 8 days after dredging the fraction of 2,3,7,8-TCDD due to dredging is a little higher in the bottom layer.

A statistical evaluation (not shown) of the upstream and downstream surface 2,3,7,8-TCDD concentration differences (at hourly intervals) when dredging is simulated at RM 6.3, indicates that on average, downstream concentrations are higher than upstream concentrations by 2.8 pg/l; downstream concentration is greater than upstream concentration by at least 9.8 pg/L 10 percent of the time and downstream is lower than upstream by at least 7.8 pg/L 10 percent of the time. 2,3,7,8-TCDD concentrations in the bottom layer differ between downstream and upstream of the dredging operation by an average of about 2.9 pg/L; downstream concentration is greater than upstream concentration by at least 18 pg/L 10 percent of the time and downstream is lower than upstream by at least 9.6 pg/L 10 percent of the time.

River Mile 4.0

Figure 10 shows the average surface layer 2,3,7,8-TCDD concentration time series results from the No Action and Selected Remedy simulations at three contiguous grid cells at RMs 4.1, 4.0, and 3.9. Dredging at this location is simulated in November 2023 when the flow conditions are within a couple hundred cfs from the annual average, but an increase of approximately 1000 cfs occurs near the end of the dredging period. The flows are even higher at the very beginning and end of the 77-day period shown on these plots. During the dredging operation the average 2,3,7,8-TCDD concentration from the No Action simulation is slightly higher than what was observed near RM 6.1 (presented above) – approximately 8 pg/L. The average dioxin concentration from the Selected Remedy simulation is approximately 69 pg/L, which is about 3 times higher as compared to the results at RM 6.3 and is similar to the average dioxin concentration at RM 8.1. Comparisons of water column concentrations computed at RM 6.3 and RM 8.1 highlight both temporal variations related to hydrodynamic conditions and the effect of grid-scale spatial variations in contaminant concentrations.

Results from the Selected Remedy simulation in which contaminants released during dredging are computed in a state variable separate from contaminants from all other sources are shown on Figures 11 and 12 (surface and bottom water column layers, respectively). As expected based on the observations from Figure 10 above (during dredging dioxin concentrations from the Selected Remedy simulations are notably higher than from No-Action), the fraction of 2,3,7,8-TCDD due to dredging releases is sometimes up to nearly 100 percent during the 7-day dredging period at RM 4.0. The high fraction of 2,3,7,8-TCDD due to dredging releases at this location is partially due to the relatively low contribution from other sources. It is worth noting that the fraction of dioxin due to dredging releases is already up at 95 percent at the beginning of the 77-day period shown on these plots due to the effects of earlier dredging operations outside the vicinity of the three cells shown.

Percentages of 2,3,7,8-TCDD originating from dredging in both the surface and bottom layers are shown on Figure 13. Similar to the previously presented results, the percentages of 2,3,7,8-TCDD from dredging releases in the surface and bottom layers are usually almost the same with some variations depending on the location of dredging, flow, and tidal conditions.

A statistical evaluation (not shown) of the upstream and downstream 2,3,7,8-TCDD surface concentration differences (at hourly intervals) when dredging is simulated at RM 4.0, indicates that differences average 8.9 pg/l; downstream concentration is greater than upstream concentration by at least 42 pg/L 10 percent of the time and downstream is lower than upstream by at least 32 pg/L 10 percent of the time. Bottom layer 2,3,7,8-TCDD differences between grid cells downstream and upstream of the dredging operation also average about 8.9 pg/l; downstream is greater than upstream by at least 62 pg/L 10 percent of the time and downstream is lower than upstream by at least 39 pg/L 10 percent of the time.

River Mile 2.0

Dredging is simulated as two concurrent operations beginning on July 1, 2020, at two locations (RM 8.3 and RM 2.6) and progresses in the downstream direction from each starting point. Therefore, the results shown on Figure 14 for three contiguous grid cells at RMs 2.1, 2.0, and 1.9 represent a time approximately six weeks after dredging commenced roughly one half mile upstream of those locations. River flows at the start of dredging at RM 2.0 are low - less than 200 cfs until the last day of dredging, when flows rise by several hundred cfs, but do not reach the annual average flow of over 1100 cfs. During the dredging operation the average 2,3,7,8-TCDD concentration at RM 2.0 from the No Action simulation is about 7 pg/L, which is comparable to the concentrations near RMs 6.3 and 4.0 but lower than at RM 8.1. Unlike the results near RMs 8.1, 6.3 and 4.0, the dioxin concentrations from the Selected Remedy do not visibly go up during the dredging operations in the three cells shown, which reflects the increased tidal dilution in areas experiencing larger tidal exchange with Newark Bay. During the 77-day period illustrated on Figure 14 the 2,3,7,8-TCDD concentrations from the Selected Remedy simulation fluctuate only from about 10 pg/L to 70 pg/L, which may be attributed to decreasing tidal amplitudes. During dredging at RM 2.0 the average dioxin concentration is 33 pg/l, a little higher than at RM 6.3 and less than half of the averages at RMs 8.1 and 4.0.

2,3,7,8-TCDD originating from dredging releases in the surface and bottom layers are shown on Figures 15 and 16, respectively. During dredging at RM 2.0 the fraction of 2,3,7,8-TCDD from dredging releases goes up from about 75 percent to 85 percent, which may be attributed to changing concentrations from all other sources due to changing tidal amplitudes. Similar to the results at upstream locations, the percentages of 2,3,7,8-TCDD from dredging releases in the surface and bottom layers are usually almost the same (Figure 17).

A statistical evaluation (not shown) of the upstream and downstream 2,3,7,8-TCDD surface concentration differences (at hourly intervals) when dredging is simulated at RM 2.0, indicates that on average the downstream concentrations are higher than upstream by 0.03 pg/l; downstream concentration is greater than upstream concentration by at least 3.4 pg/L 10 percent of the time and downstream is lower than upstream by at least 5.3 pg/L 10 percent of the time. In the bottom layer the downstream concentrations are lower than upstream by 2.2 pg/l; downstream concentration is greater than upstream concentration by at least 2.6 pg/L 10 percent of the time and downstream is lower than upstream by at least 7.7 pg/L 10 percent of the time.

River Mile 0.2

Figure 18 shows the surface layer 2,3,7,8-TCDD concentration time series results from the No Action and Selected Remedy simulations at three contiguous model grid cells near RMs 0.3 and 0.2. Dredging at this location is simulated during a period of low flow with a short transient in flows ranging from approximately a low of 100 cfs to a high of 500 cfs. During the dredging period the average 2,3,7,8-TCDD concentration from the No Action simulation is about 4 pg/L, which is lower than the results at the upstream locations. The average dioxin concentration from the Selected Remedy simulation is also lower than in the previously presented results at more upstream locations of approximately 17 pg/L. After the dredging operation at RM 0.2 is completed, the dioxin concentration continues to increase due to the subsequent dredging of the adjacent cell immediately to the west.

Figures 19 and 20 show the time series of 2,3,7,8-TCDD originating from releases during dredging in the surface and bottom layers, respectively. During the active dredging at RM 0.2, the fraction of dioxin originating from dredging releases goes up from about 85 percent to 90 percent and then continues to increase for the next 8 days due to the dredging in the cell immediately west of it. Figure 21 compares the time series of the dioxin fractions from dredging releases in both the surface and bottom layers. As in the previously presented results for more upstream locations, the percentages of 2,3,7,8-TCDD from dredging releases in the surface and bottom layers are usually almost the same.

A statistical evaluation (not shown) of the upstream and downstream 2,3,7,8-TCDD surface concentration differences (at hourly intervals) when dredging is simulated at RM 0.2, indicates that on average downstream concentrations are higher than upstream concentrations by 0.2 pg/l; downstream concentration is greater than upstream concentration by at least 5.4 pg/L 10 percent of the time and downstream is lower than upstream by at least 5.1 pg/L 10 percent of the time. In the bottom layer downstream 2,3,7,8-TCDD concentrations are higher than upstream by 0.7 pg/L; downstream concentration is greater than upstream concentration by at least 6.6 pg/L 10 percent of the time and downstream is lower than upstream by at least 5.4 pg/L 10 percent of the time.

Sum of tetrachloro biphenyl congeners

In this section Tetra PCB results are presented for the same stations presented for 2,3,7,8-TCDD above.

River Mile 8.1

Figure 22 presents Tetra PCB concentration time series for the top layer of the water column from the No-Action and Selected Remedy model simulations. From top to bottom, the three panels present results for contiguous collapsed model grid cells at RM 8.2, 8.1, and 8.0, respectively. During the dredging period the average Tetra PCB concentration from the No Action simulation is about 14 ng/L. The average Tetra PCB concentration from the Selected Remedy simulation is approximately 35 ng/L. The Tetra PCB concentrations appear to be fluctuating with changing tidal amplitudes but do not display a notable increase during the dredging operation, as the variations are dominated by intra-tidal remobilization of Tetra-PCBs previously released from adjacent cells (note elevated concentrations before dredging begins in the cell at RM 8.2) and the variations in both river flow and tidal amplitude.

The surface and bottom layer Tetra PCB concentrations originating from dredging releases based on the simulation on the finer sediment transport grid are shown on Figures 23 and 24, respectively. During the active dredging period the percent of Tetra PCB from dredging releases is at about 65 percent. At the beginning of the 77 day period shown on these plots, the percent of Tetra PCB from dredging releases is at about 75 percent likely due to the preceding dredging in the cells west of the three shown. Overall the fluctuations in percent of Tetra PCB from dredging releases appear to be driven mostly by the fluctuations in the Tetra PCB concentrations from dredging releases, which vary more on an intra-tidal basis than do the concentrations originating from all other sources.

Figure 25 compares the percent of Tetra PCB from dredging releases for surface and bottom layers. Similar to the 2,3,7,8-TCDD results presented previously, the fractions of Tetra PCB from dredging releases in the surface and bottom layers are almost the same although the surface values seem to fluctuate a little more.

A statistical evaluation (not shown) of the upstream and downstream surface Tetra PCB concentration differences (at hourly intervals) when dredging is simulated at RM 8.1, indicates that on average downstream concentrations are higher than upstream concentrations by 0.8 ng/l; downstream concentration is greater than upstream concentration by at least 3.1 pg/L 10 percent of the time and downstream is lower than upstream by at least 1.9 pg/L 10 percent of the time. In the bottom layer downstream Tetra PCB concentrations are lower than upstream by 0.3 ng/L; downstream concentration is greater than upstream concentration by at least 2.6 pg/L 10 percent of the time and downstream is lower than upstream by at least 3.1 pg/L 10 percent of the time. Tetra PCBs in the bottom layer of the water column, which on average are higher upstream as compared to downstream of the dredging is the result estuarine circulation during the low flow conditions during the period when dredging is simulated at this location.

River Mile 6.3

The surface layer Tetra PCB concentration time series results from the No Action and Selected Remedy simulations at three contiguous collapsed grid cells at RMs 6.5, 6.3, and 6.1 are shown on Figure 26. During the dredging operation at RM 6.3 the average Tetra PCB concentration from the No Action simulation is about 3 times lower than what was observed near RM 8.1 (presented above) – approximately 4 ng/L. The average Tetra PCB concentration from the Selected Remedy simulation is about 10 ng/L, which is also 3 times lower as compared to the results at RM 8.1.

Figures 27 and 28 present Tetra PCB concentrations from dredging releases and all other sources and percent of Tetra PCB from dredging releases in the surface and bottom layers, respectively, from the Selected Remedy simulation on the finer sediment transport grid. Similar to the results near RM 8.1, the percent of Tetra PCB from dredging releases is about 65 percent during the active dredging period.

Comparing the surface and bottom percent of Tetra PCB from dredging releases (Figure 29) it appears that during dredging at RM 6.3 the surface and bottom values are almost the same. Immediately after dredging the percent of Tetra PCB from dredging releases drops more rapidly in the surface layer.

A statistical evaluation (not shown) of the differences in average hourly surface layer Tetra PCB concentrations when dredging is simulated near RM 6.3 indicates that on average downstream concentrations are higher than upstream concentrations by 0.8 ng/l; downstream concentration is greater than upstream concentration by at least 2.9 pg/L 10 percent of the time and downstream is lower than upstream by at least 2.2 pg/L 10 percent of the time. In the bottom layer downstream Tetra PCB concentrations are higher than upstream by 1.7 ng/L; downstream concentration is greater than upstream concentration by at least 8.1 pg/L 10 percent of the time and downstream is lower than upstream by at least 3.3 pg/L 10 percent of the time.

River Mile 4.0

Figure 30 shows the surface layer Tetra PCB concentration time series results from the No Action and Selected Remedy simulations at three contiguous collapsed grid cells at RMs 4.1, 4.0, and 3.9. During the dredging operation the average Tetra PCB concentration from the No Action simulation is approximately 5 ng/L. The average Tetra PCB concentration from the Selected Remedy simulation is about 17 ng/L. Unlike at RM 6.3, during dredging at RM 4.0 there is a clear increase in the Tetra PCB concentrations from the Selected Remedy simulation.

Results from the Selected Remedy simulation in which hourly average surface and bottom Tetra PCB concentrations released during dredging are computed in a state variable separate from Tetra PCB concentrations from all other sources are shown on Figures 31 and 32, respectively. During dredging the average percent of Tetra PCB from dredging releases is about 80 percent. Prior to and after the dredging operation, on average about 40 percent of total Tetra PCB originates from dredging releases. The percent of Tetra PCB from dredging releases in the surface and bottom layers are compared on Figure 33. It appears that during dredging the surface and bottom layers have similar values, while after dredging the percent of Tetra PCB from dredging releases in the bottom layer decreases faster.

A statistical evaluation (not shown) of the downstream and upstream differences in 15-minute average surface layer Tetra PCB concentrations when dredging is simulated near RM 4.0, indicates that the differences average at about 1.7 ng/l; downstream is higher than upstream by at least 8.9 ng/l 10 percent of the time; upstream is higher than downstream by at least 6.2 ng/l 10 percent of the time. The differences in Tetra PCB concentrations between upstream and downstream in the bottom layer also average about 1.7 ng/L; downstream is higher than upstream by at least 13 ng/l 10 percent of the time; upstream is higher than downstream by at least 8.0 ng/l 10 percent of the time.

River Mile 2.0

The results shown on Figure 34 for three contiguous grid cells at RMs 2.1, 2.0, and 1.9 represent a time approximately six weeks after dredging commenced roughly one half mile upstream of RM 8.3 and RM 2.6. River flows during the dredging period at RM 2.0 are mostly below 200 cfs but occasionally increase up to 1000 cfs. During the dredging operation the average Tetra PCB concentrations at RM 2.0 from the No Action simulation is about 14 ng/L, which is the same as at RM 8.1 but lower than near RMs 6.3 and 4.0 . During the dredging period illustrated on Figure 34 the average Tetra PCB concentration from the Selected Remedy is about 28 ng/l.

Tetra PCB concentrations originating from dredging releases in the surface and bottom layers are shown on Figures 35 and 36, respectively. The percent of Tetra PCB from dredging releases range from about 20 percent to 75 percent without a very notable increase during the dredging operation at RM 2.0. Changing concentrations from all other sources due to changing tidal amplitudes seem to be driving the fluctuations in percent of Tetra PCB originating from dredging releases.

The difference in percent of Tetra PCB from dredging releases in the surface and bottom layers appears to be more pronounced at this location (Figure 37) as compared to the previously presented results at more upstream locations. Tetra PCB from dredging releases comprises a larger fraction of the total concentration in the surface layer because the concentrations from all other sources are lower.

A statistical evaluation (not shown) of the differences in hourly average surface layer Tetra PCB concentrations during dredging indicate that on average the downstream concentrations are greater than upstream by 0.7 ng/l; downstream is higher than upstream by at least 4.6 ng/l 10 percent of the time; upstream is higher than downstream by at least 5.0 ng/l 10 percent of the time. In the bottom layer downstream Tetra PCB concentrations are lower than upstream by 1.7 ng/L; downstream is higher than upstream by at least 2.9 ng/l 10 percent of the time; upstream is higher than downstream by at least 6.4 ng/l 10 percent of the time.

River Mile 0.2

Figure 38 shows the surface layer Tetra PCB time series results from the No-Action and Selected Remedy simulations at three contiguous collapsed model grid cells near RMs 0.3 and 0.2. Dredging at this location is simulated during a period of low flow with a short transient in flows ranging from approximately a low of 100 cfs to a high of 500 cfs. During dredging at RM 0.2, the average Tetra PCB concentration from the No-Action simulation is about 12 ng/l. The average Tetra PCB concentration from the Selected Remedy simulation is approximately 19 ng/L.

Figures 39 and 40 show the time series of Tetra PCB concentrations originating from releases during dredging in the surface and bottom layers, respectively. During the active dredging at RM 0.2, the fraction of Tetra PCB originating from dredging releases is about 55 percent. Figure 41 shows that when dredging is ongoing at the most downstream cell the percentages of Tetra PCB from dredging releases are almost the same in the surface and bottom layers of the water column. After dredging is completed the percent of contaminant from dredging releases decreases more rapidly in the bottom layer of the water column.

A statistical evaluation (not shown) of the differences in hourly average surface layer Tetra PCB concentrations when dredging is simulated at RM 0.2 indicates that on average downstream concentrations are higher than upstream by 0.7 ng/l; downstream is higher than upstream by at least 4.3 ng/l 10 percent of the time; upstream is higher than downstream by at least 3.7 ng/l 10 percent of the time. In the bottom layer downstream Tetra PCB concentrations are higher than upstream by 0.5 ng/L; downstream is higher than upstream by at least 4.4 ng/l 10 percent of the time; upstream is higher than downstream by at least 3.5 ng/l 10 percent of the time.

Conclusions

Comparisons of model simulation results for the Selected Remedy and No Action Alternative, and analysis of results from a new simulation (with an additional contaminant state variable to track the movement of contaminants released into the water column during dredging) provide information to inform development of monitoring options that will be part of the engineering performance standards.

- Simultaneous dredging at multiple locations combined with tidal circulation results in mixing of contaminants released during dredging along the length of the river. This mixing generally makes it difficult to distinguish differences between computed values upstream and downstream of dredging operations because these differences are generally small compared to the total concentration. By comparing No Action to the Selected Remedy and using the model simulation tracking dredging releases there is a clearer picture of the system's response to dredging operations. Water column concentrations during dredging for the Selected Remedy are two or more times greater than the No Action case, with the fraction of contaminants due to dredging releases generally dominating the total concentration, and input from other sources decreasing over the course of remediation.
- 2,3,7,8-TCDD measurements would be useful in detecting the contaminant releases related to dredging, but laboratory turn around time may make that impractical. Total PCB measurements may be useful for detecting excursions from expected conditions if sufficient data is collected to define baseline conditions..
- Near-field spatial and/or temporal changes in contaminants associated with solids releases during dredging vary with location within the river, dredging sequence, and in response to river flow and tidal conditions during the period of construction, which will need to be factored into the performance standards.

- Use of an additional state variable to track contaminants released during dredging provides insight beyond the simple comparison of results from simulations with and without dredging. Results from the release-tracking simulations quantify the degree to which solids and contaminants originating from releases during dredging replace native sediment in the overall sediment transport process (i.e. solids released during dredging represent concentrations greater than the difference between results from simulations with and without dredging). This leads to the conclusion that monitoring solids (or surrogates) will need to be supplemented with chemical measurements to evaluate compliance with acceptable construction performance.

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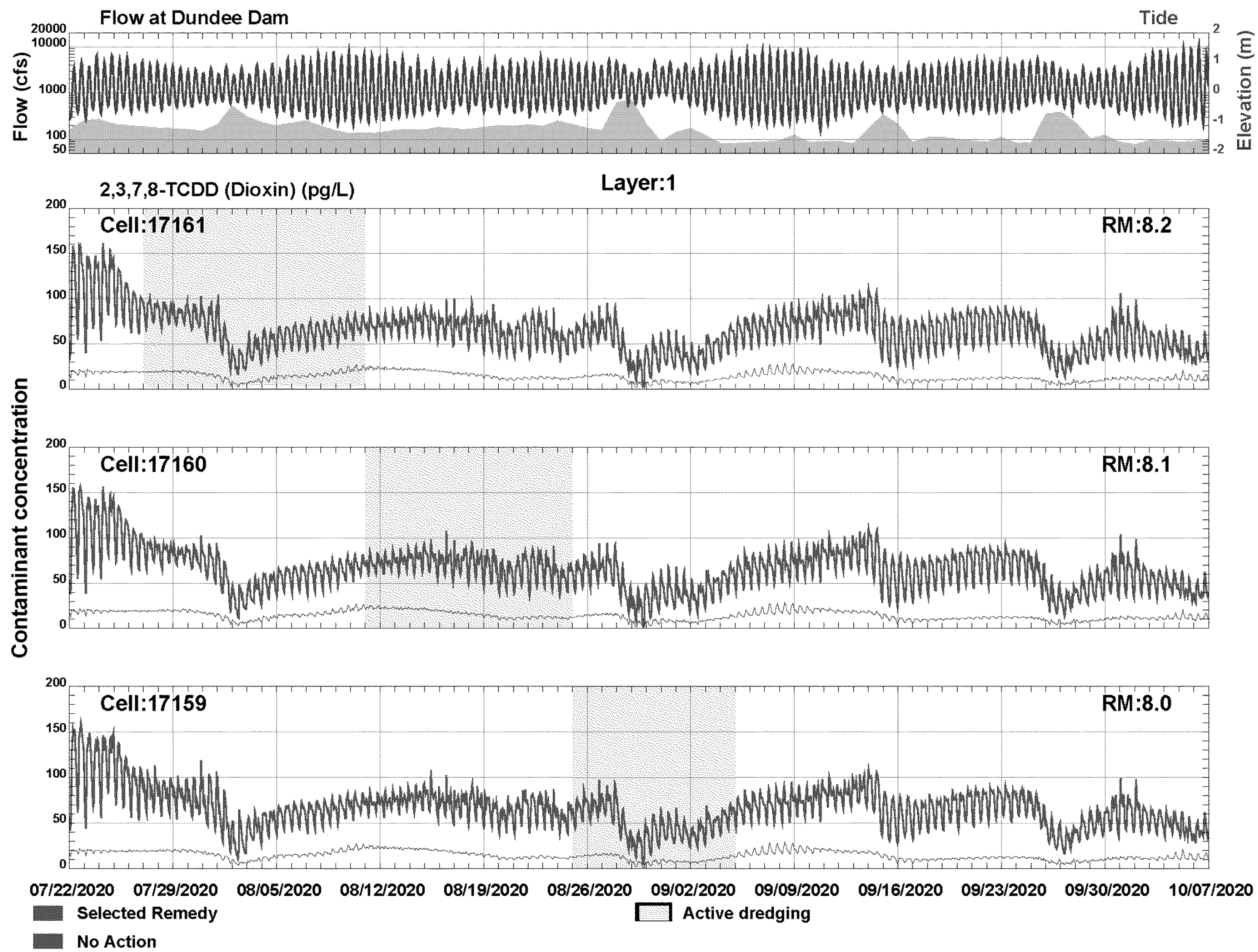
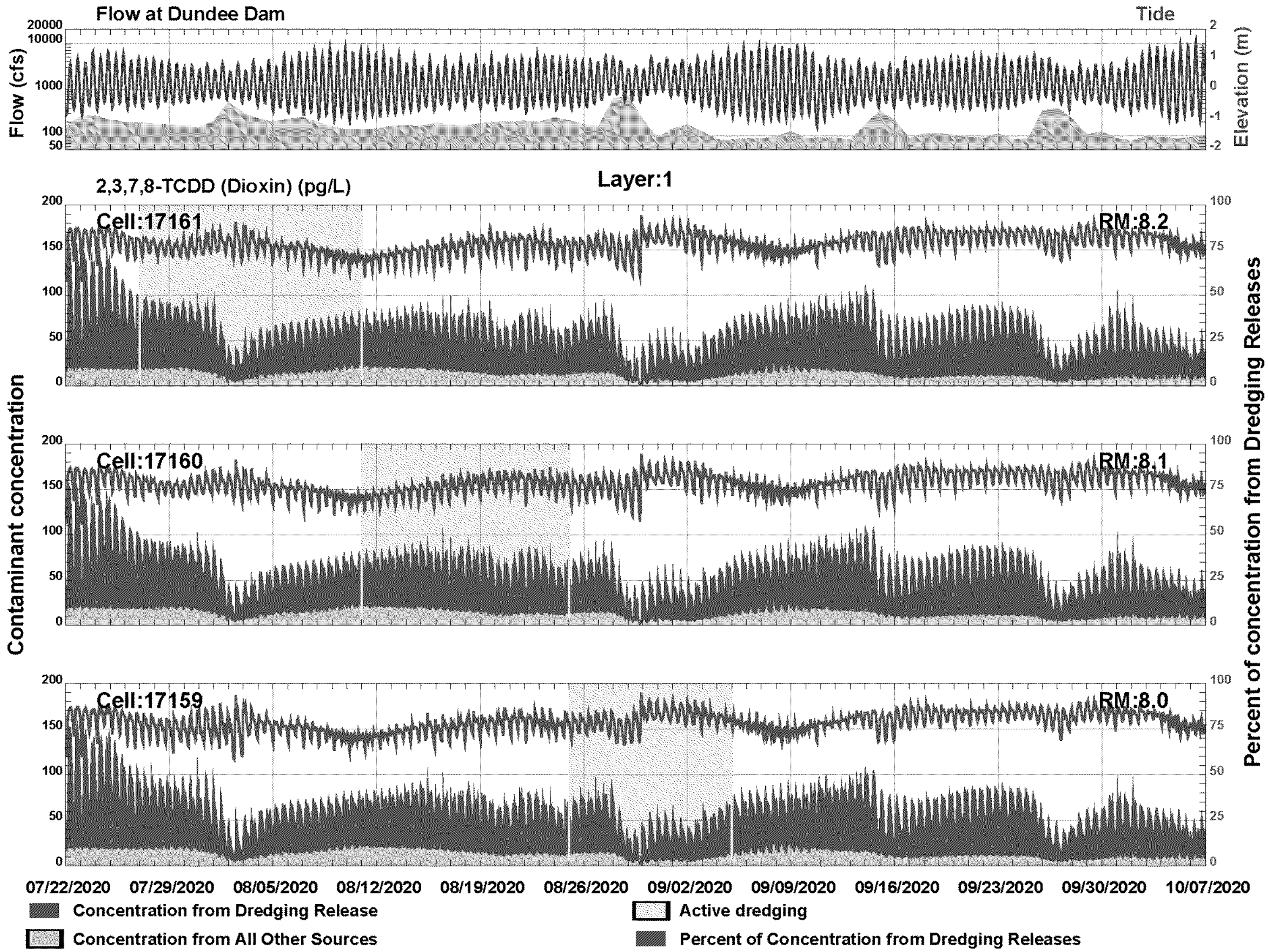
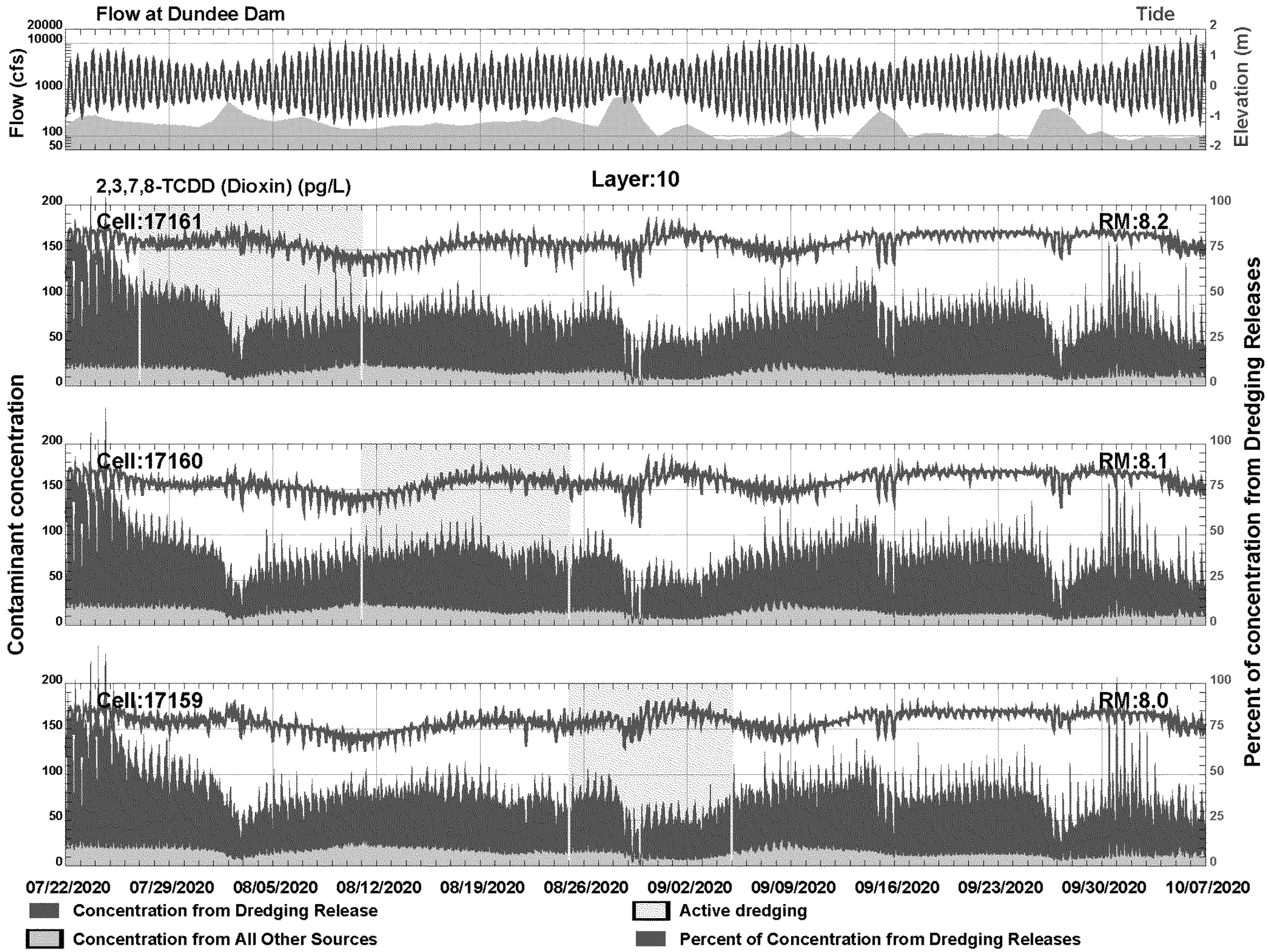
Dredging Schedule for Selected Remedy	Figure 1
Lower 8.3 Miles of the Lower Passaic River	2016



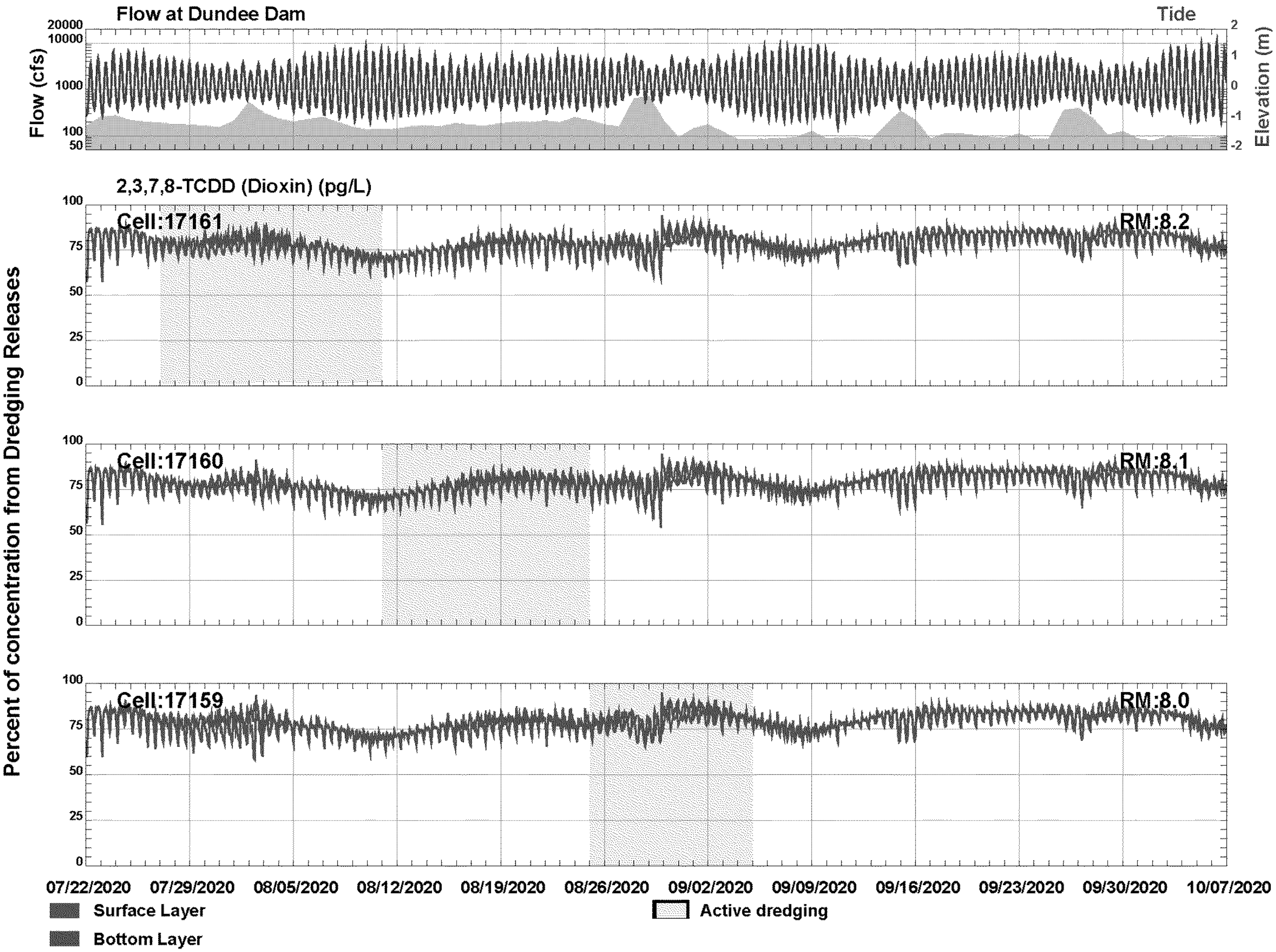
Comparison of 2,3,7,8-TCDD concentrations from Selected Remedy and No Action near RM 8.1 surface layer (Assumption: resuspension loss is 3% of dredged mass)	Figure 2
Lower 8.3 Miles of the Lower Passaic River	2016



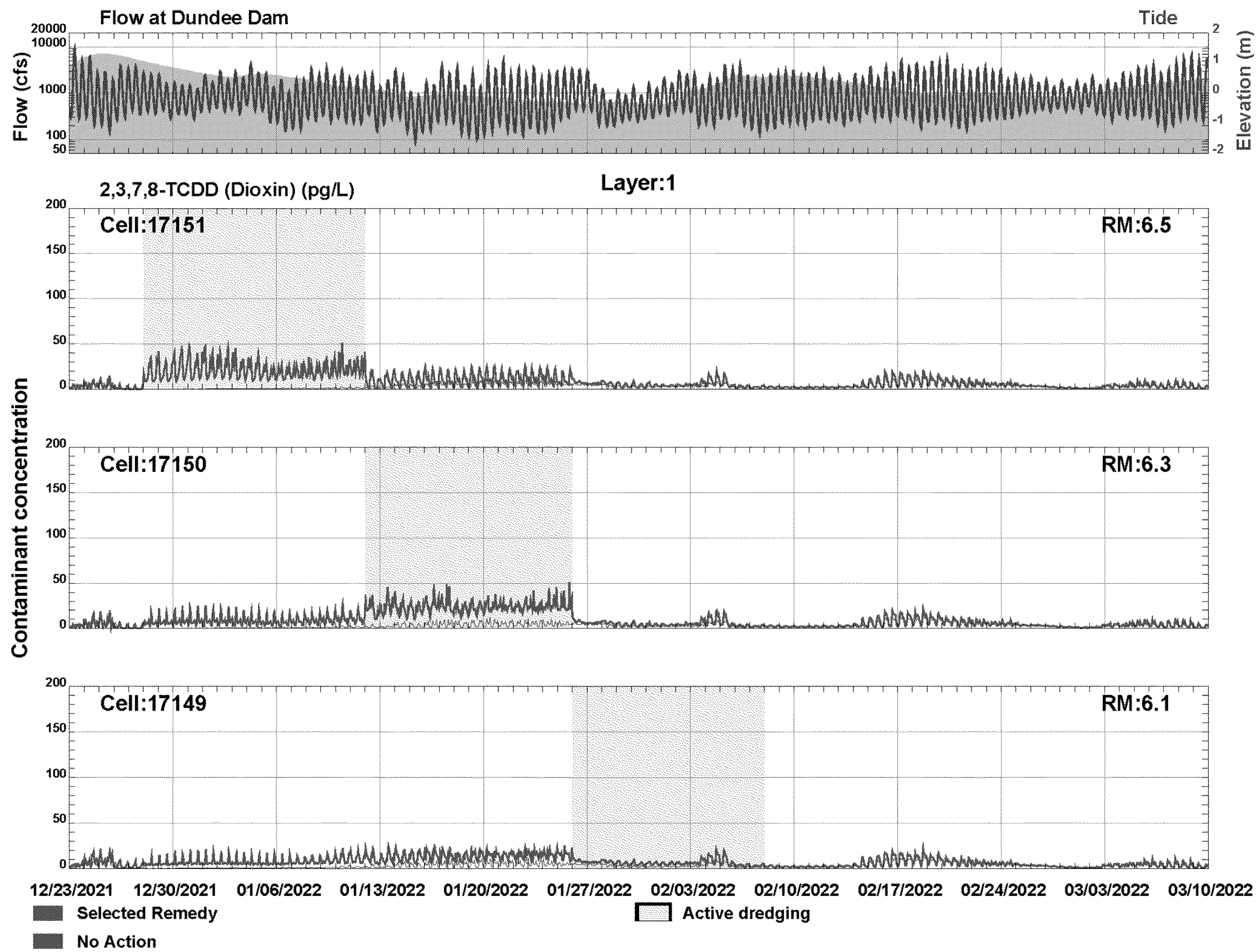
2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 8.1 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 3 2016



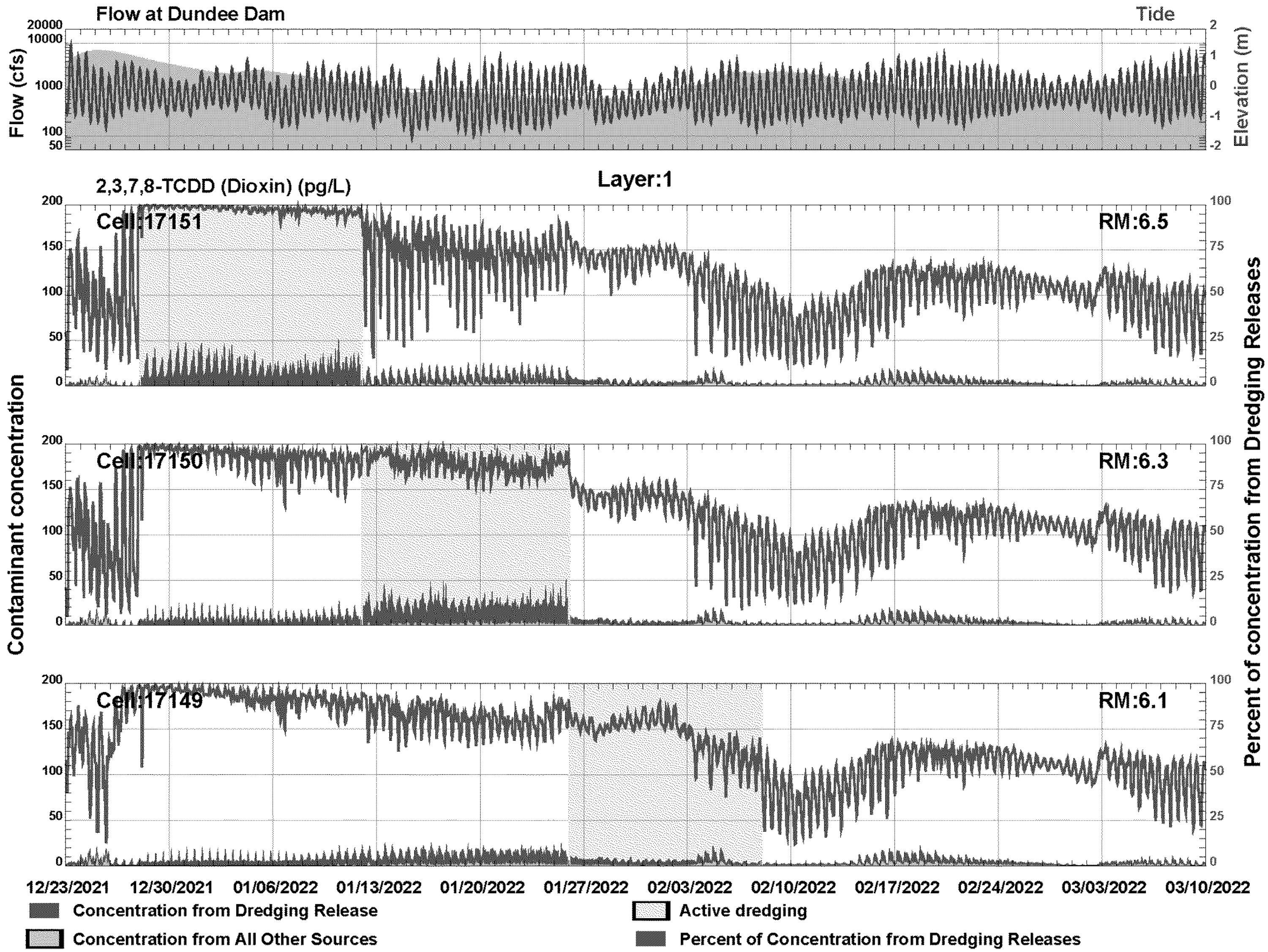
2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 8.1 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 4 2016



Percentage of 2,3,7,8-TCDD from dredging releases near RM 8.1 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 5 2016



Comparison of 2,3,7,8-TCDD concentrations from Selected Remedy and No Action near RM 6.3 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 6 2016

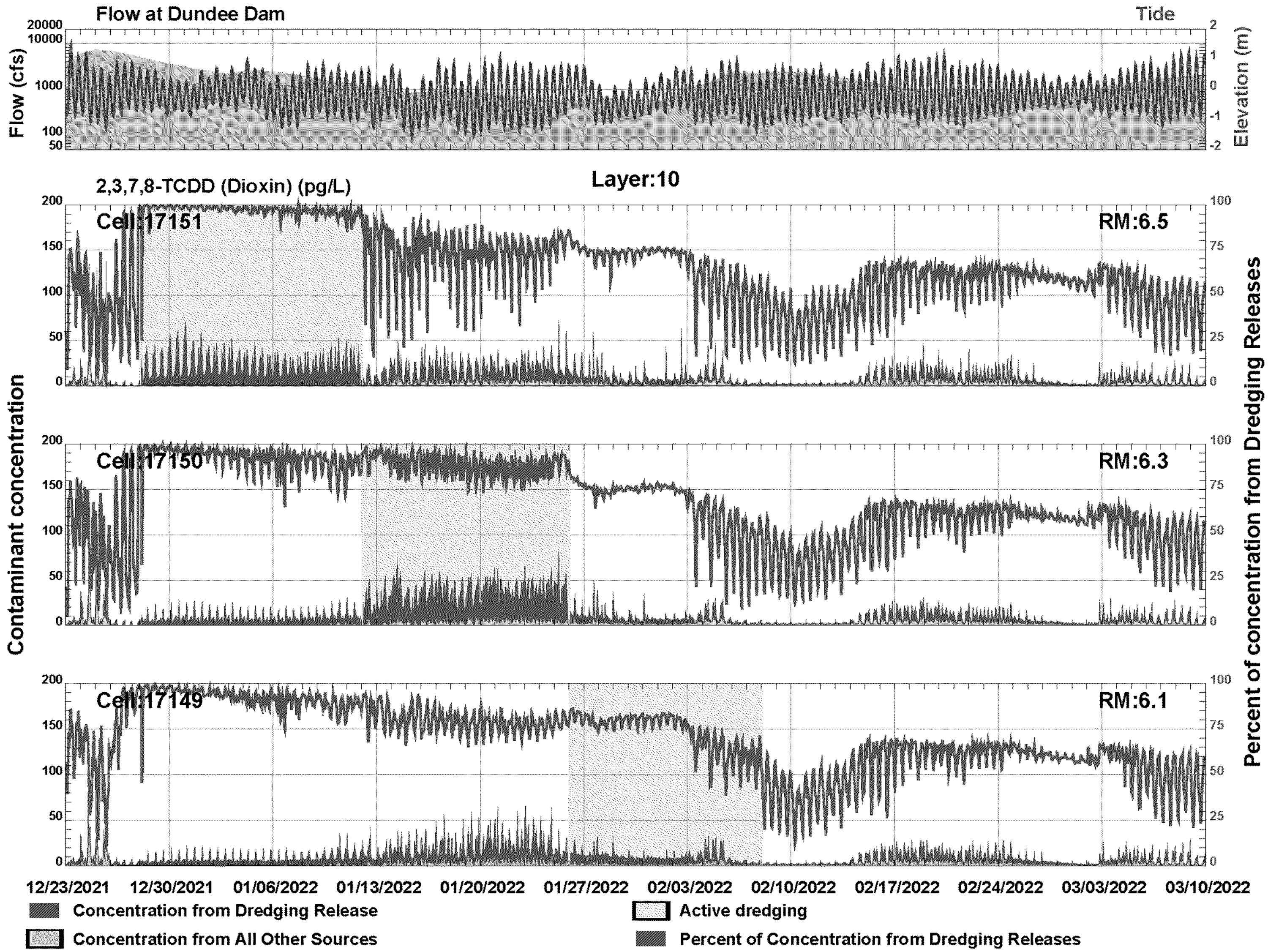


2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 6.3 surface layer (Assumption: resuspension loss is 3% of dredged mass)

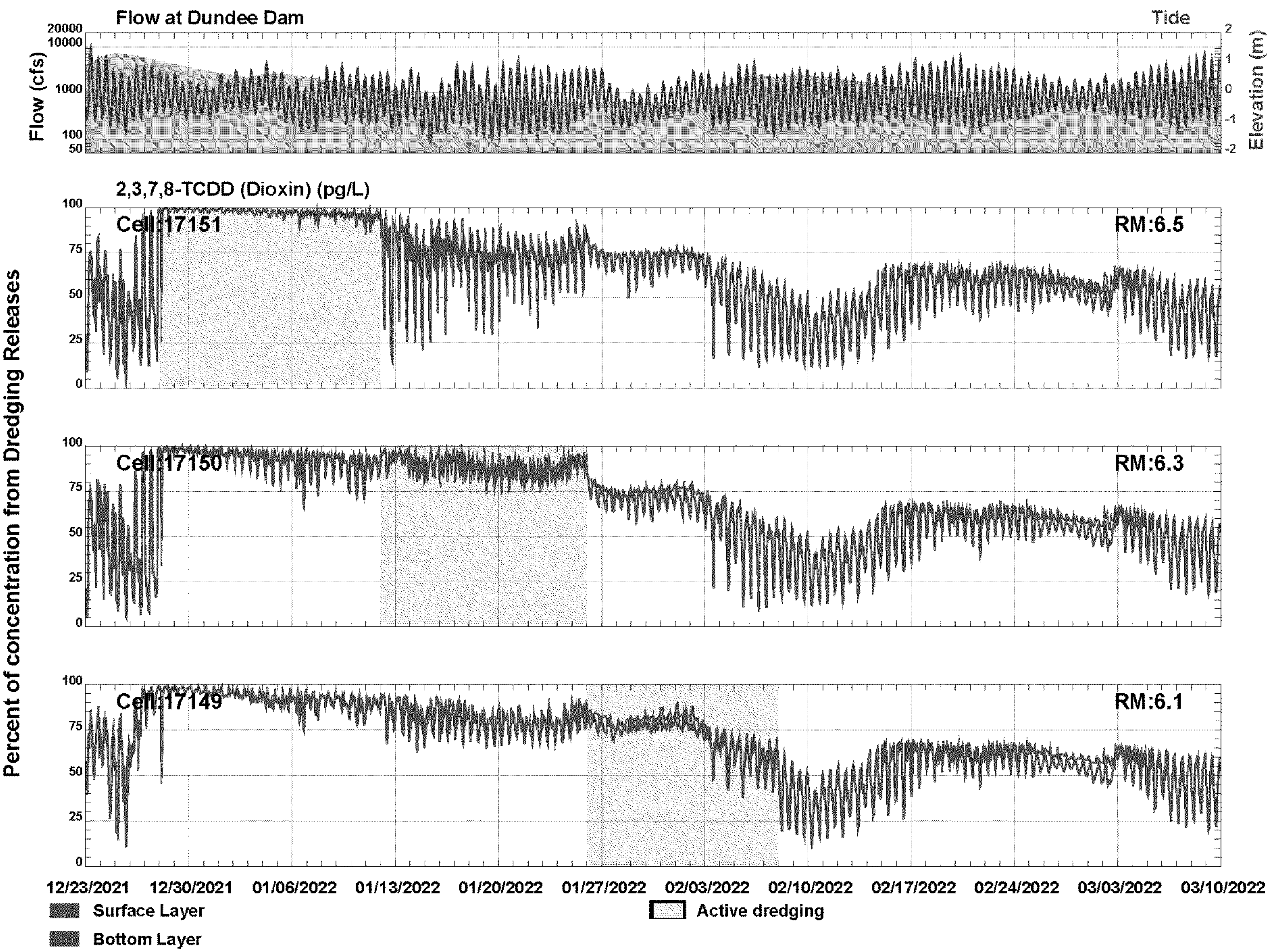
Lower 8.3 Miles of the Lower Passaic River

Figure 7

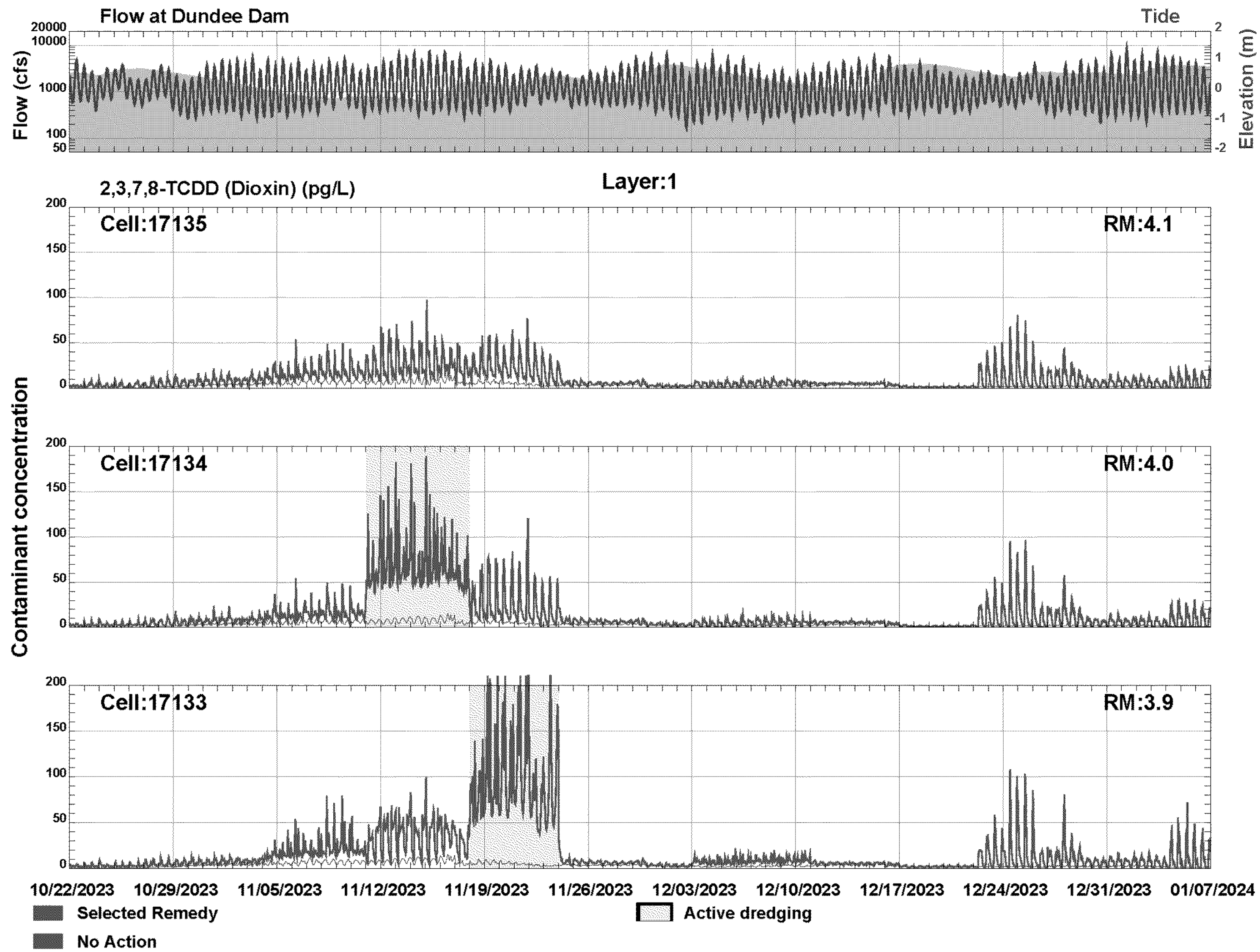
2016



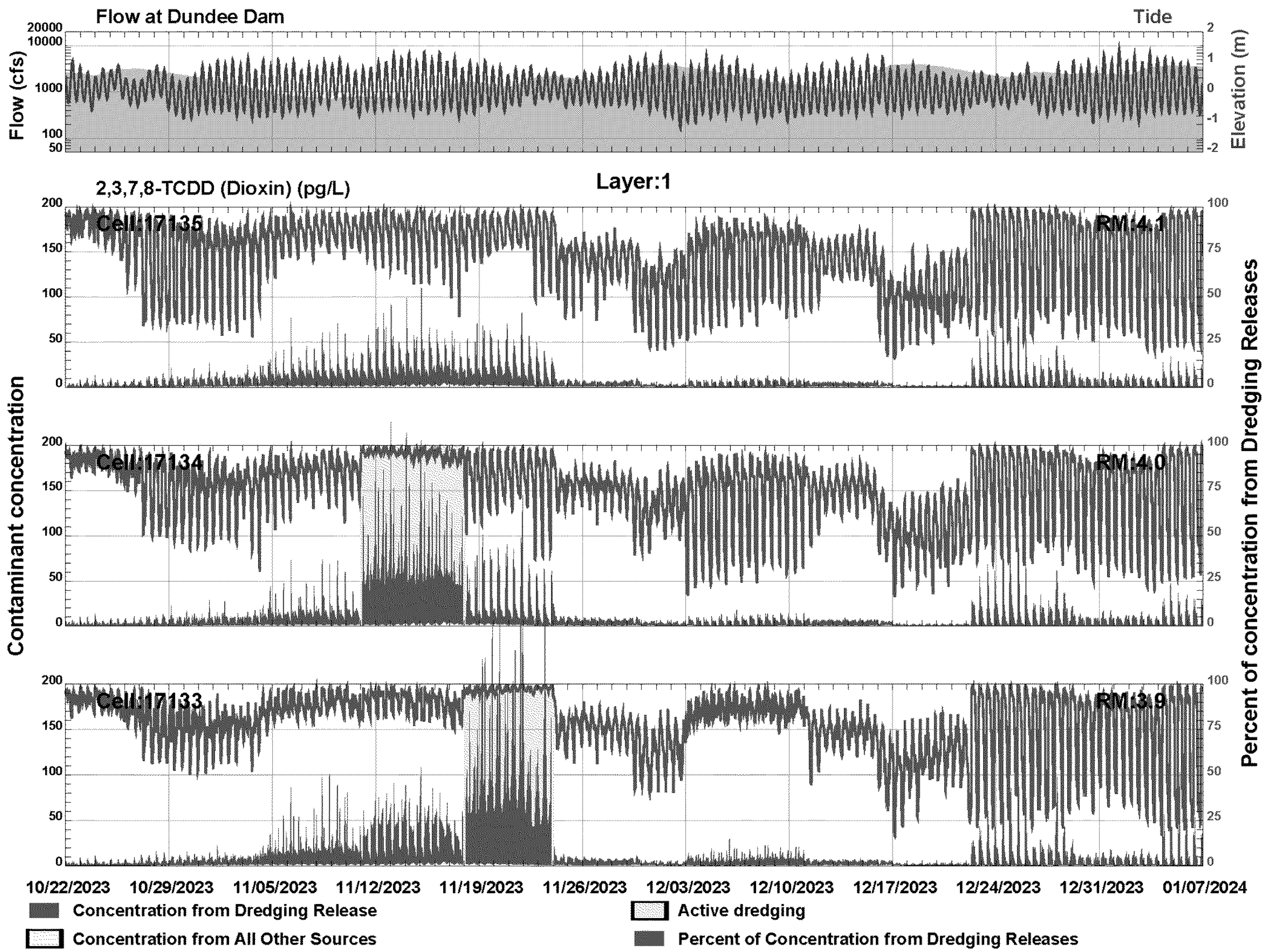
2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 6.3 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 8 2016



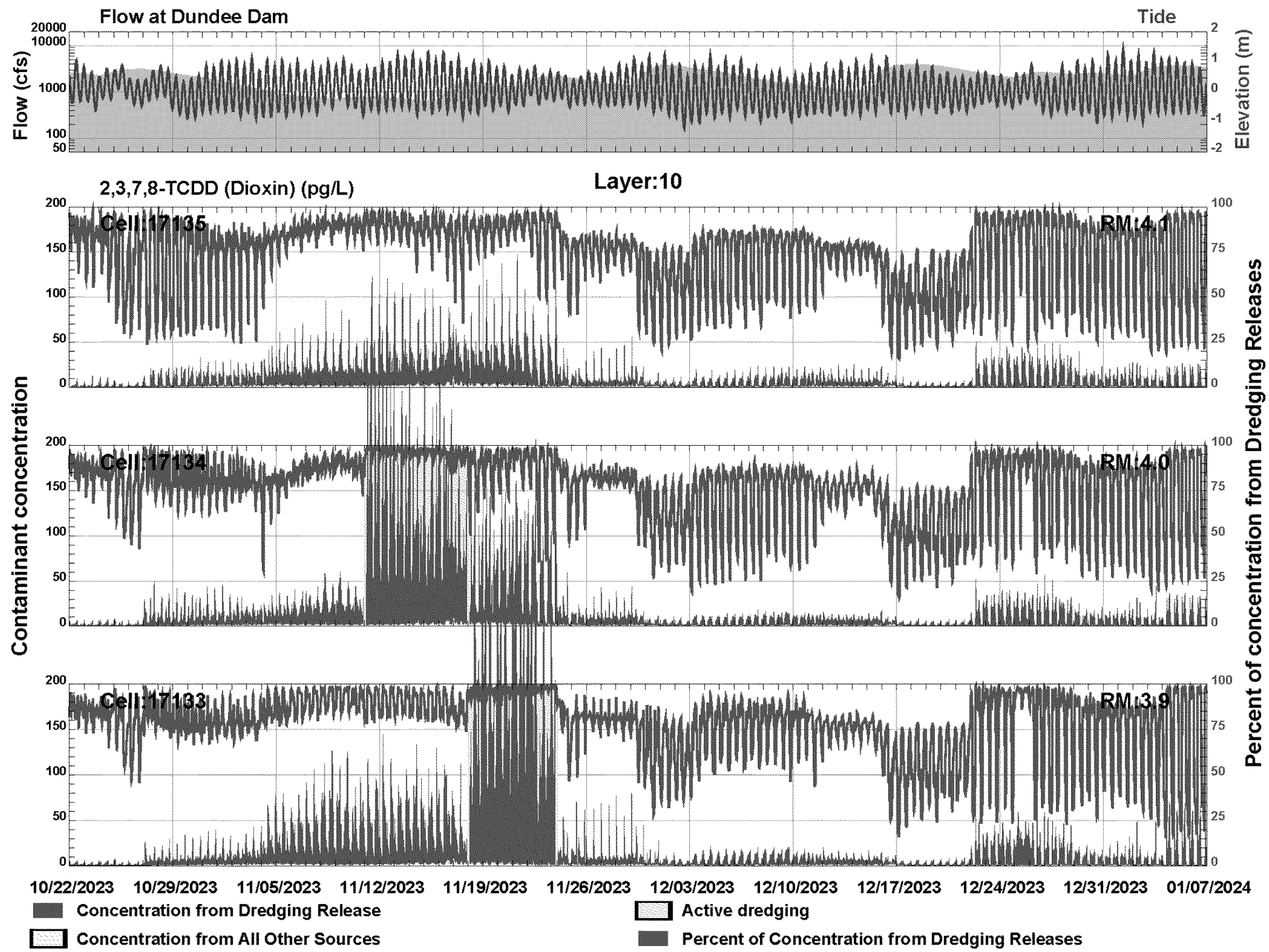
Percentage of 2,3,7,8-TCDD from dredging releases near RM 6.3 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 9 2016



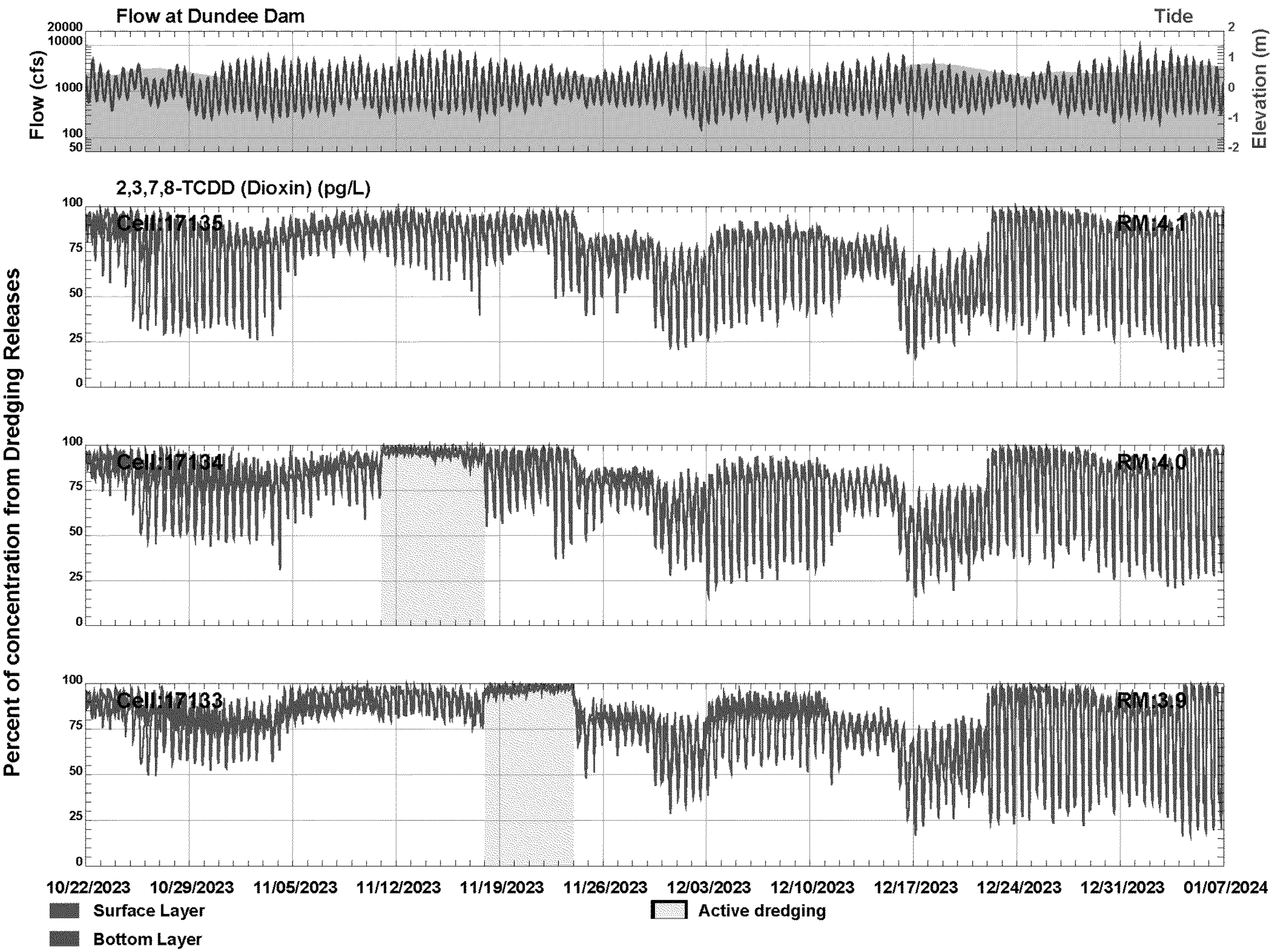
Comparison of 2,3,7,8-TCDD concentrations from Selected Remedy and No Action near RM 4.0 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 10
	2016



2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 4.0 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 11 2016



2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 4.0 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 12 2016

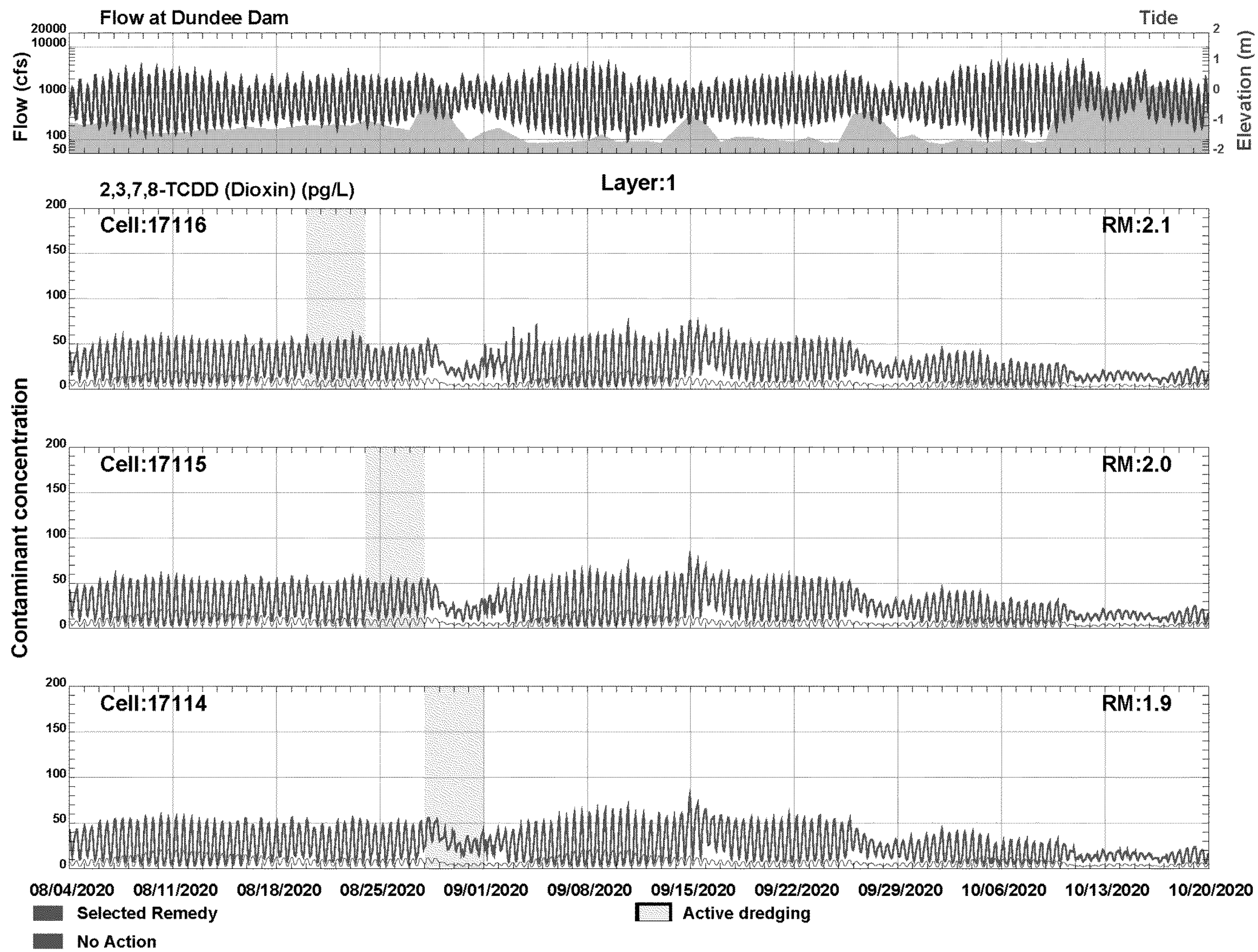


Percentage of 2,3,7,8-TCDD from dredging releases near RM 4.0 (Assumption: resuspension loss is 3% of dredged mass)

Lower 8.3 Miles of the Lower Passaic River

Figure 13

2016

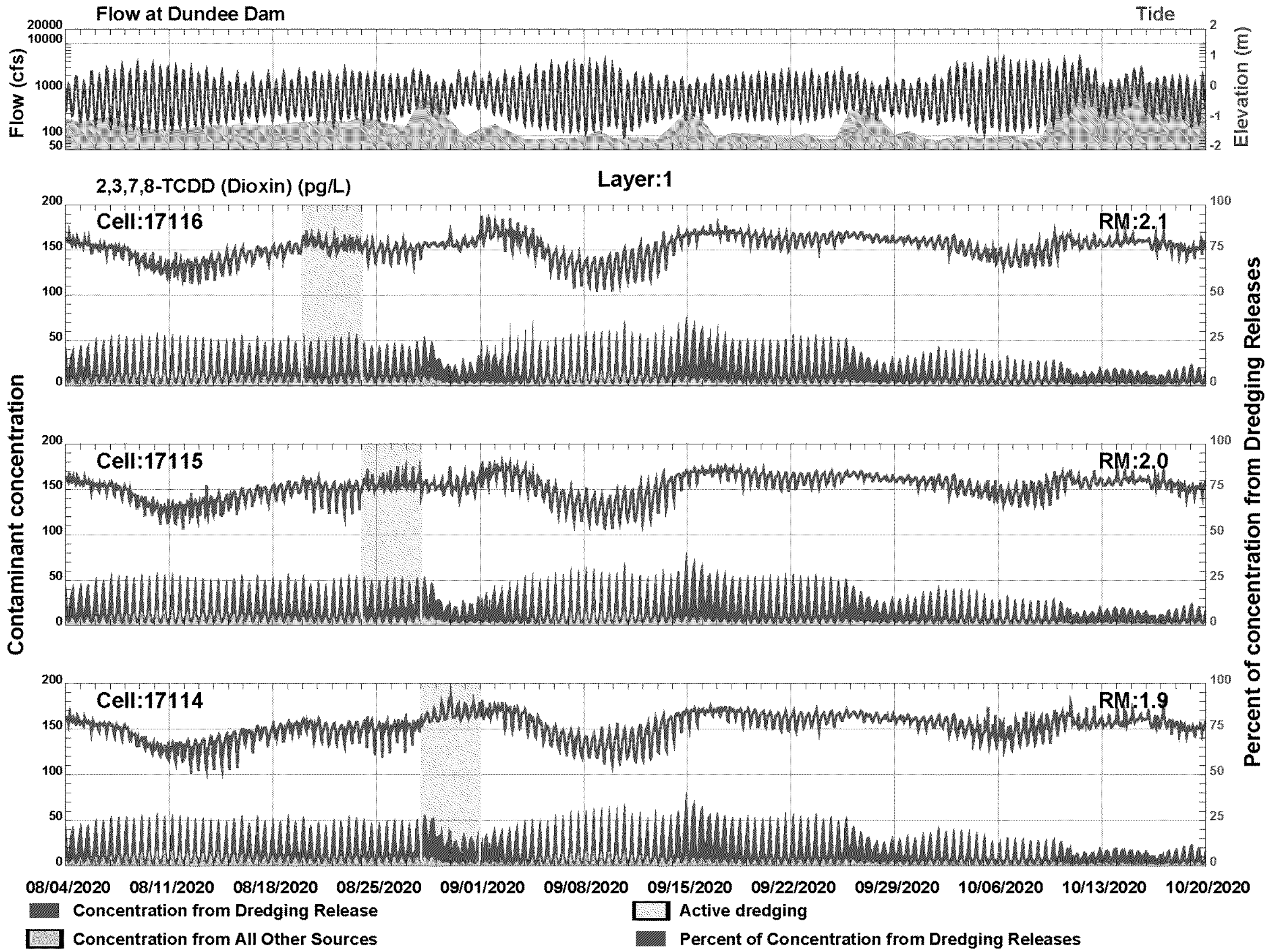


Comparison of 2,3,7,8-TCDD concentrations from Selected Remedy and No Action near RM 2.0 surface layer (Assumption: resuspension loss is 3% of dredged mass)

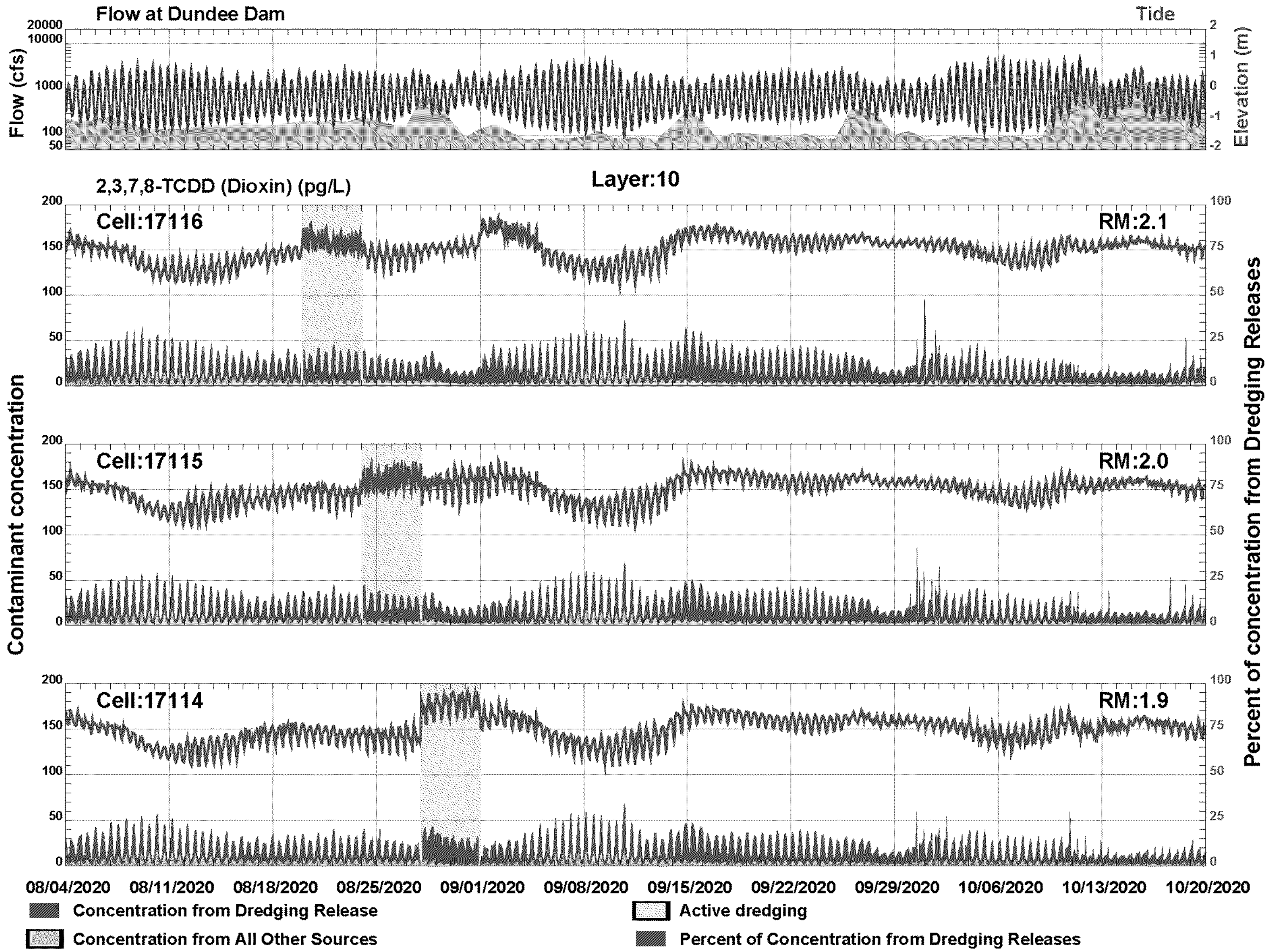
Lower 8.3 Miles of the Lower Passaic River

Figure 14

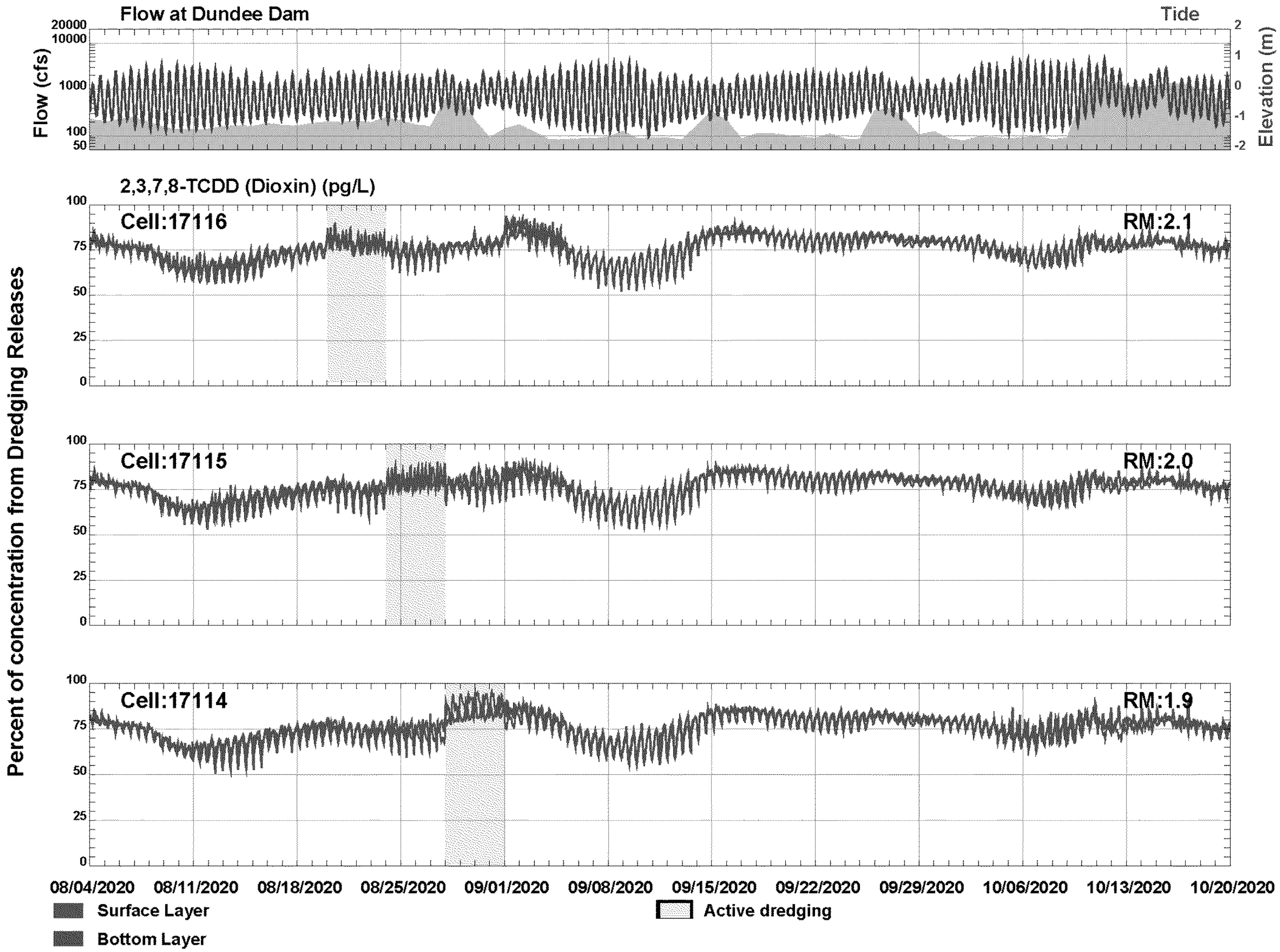
2016



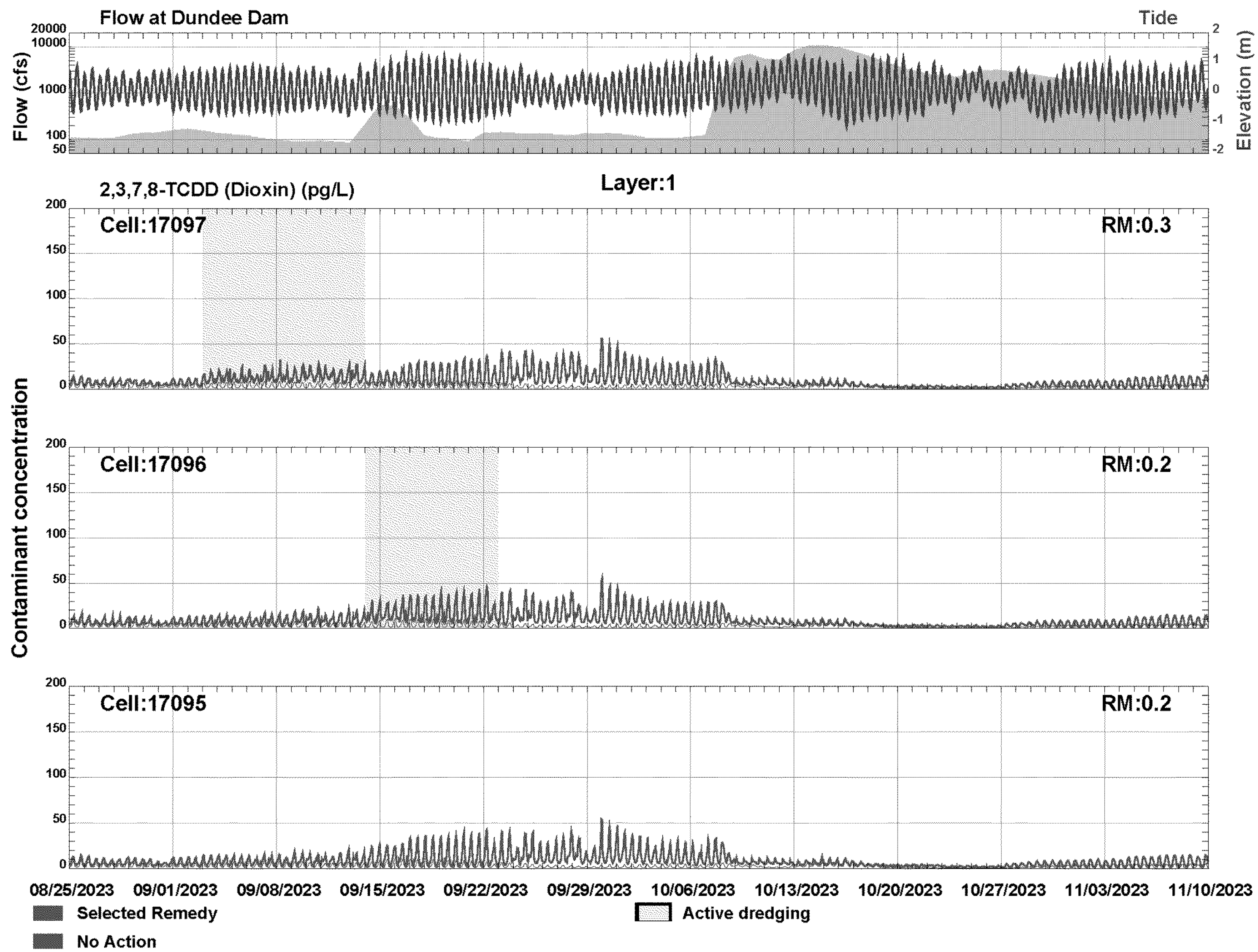
2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 2.0 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 15 2016



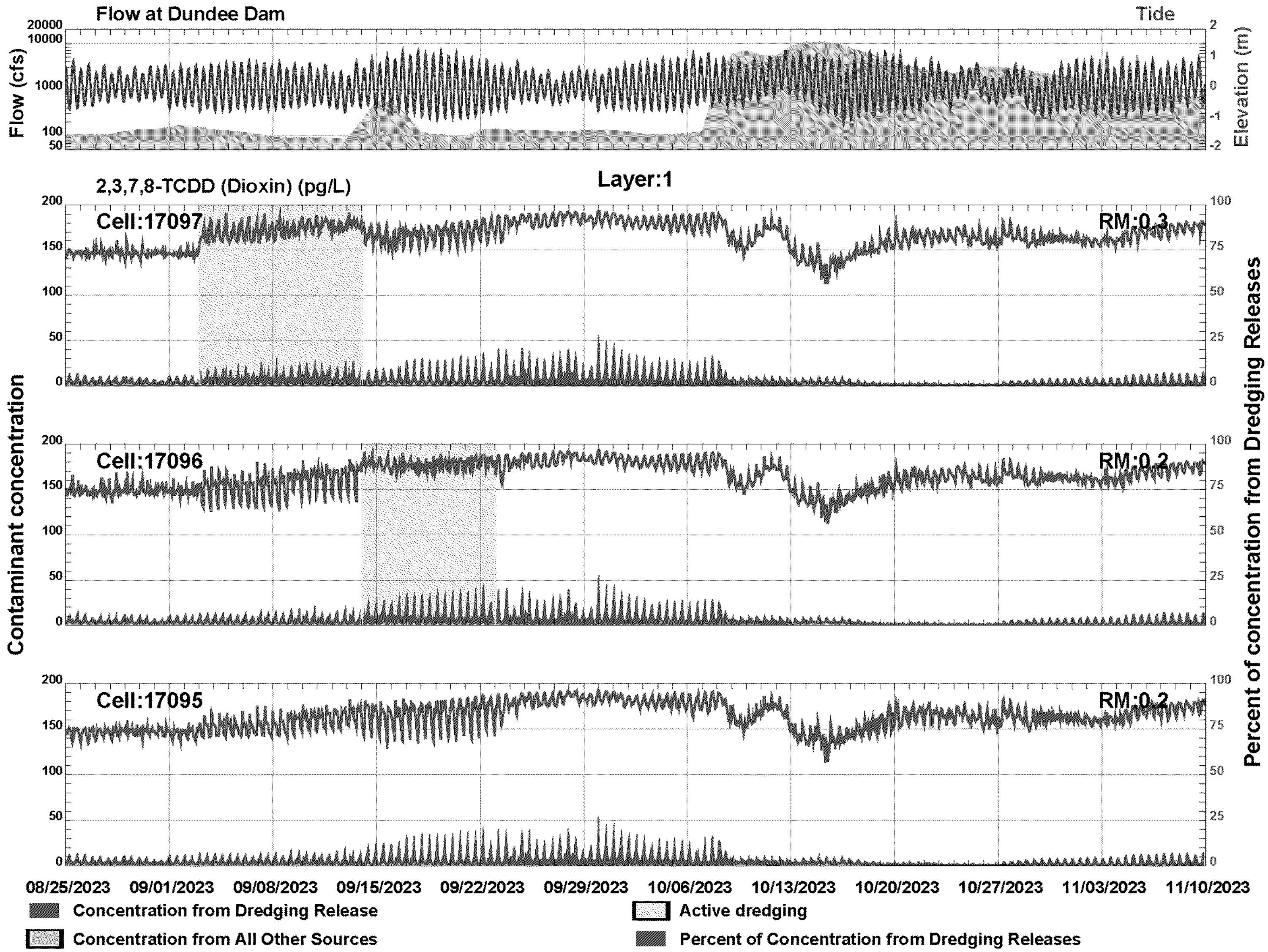
2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 2.0 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 16 2016



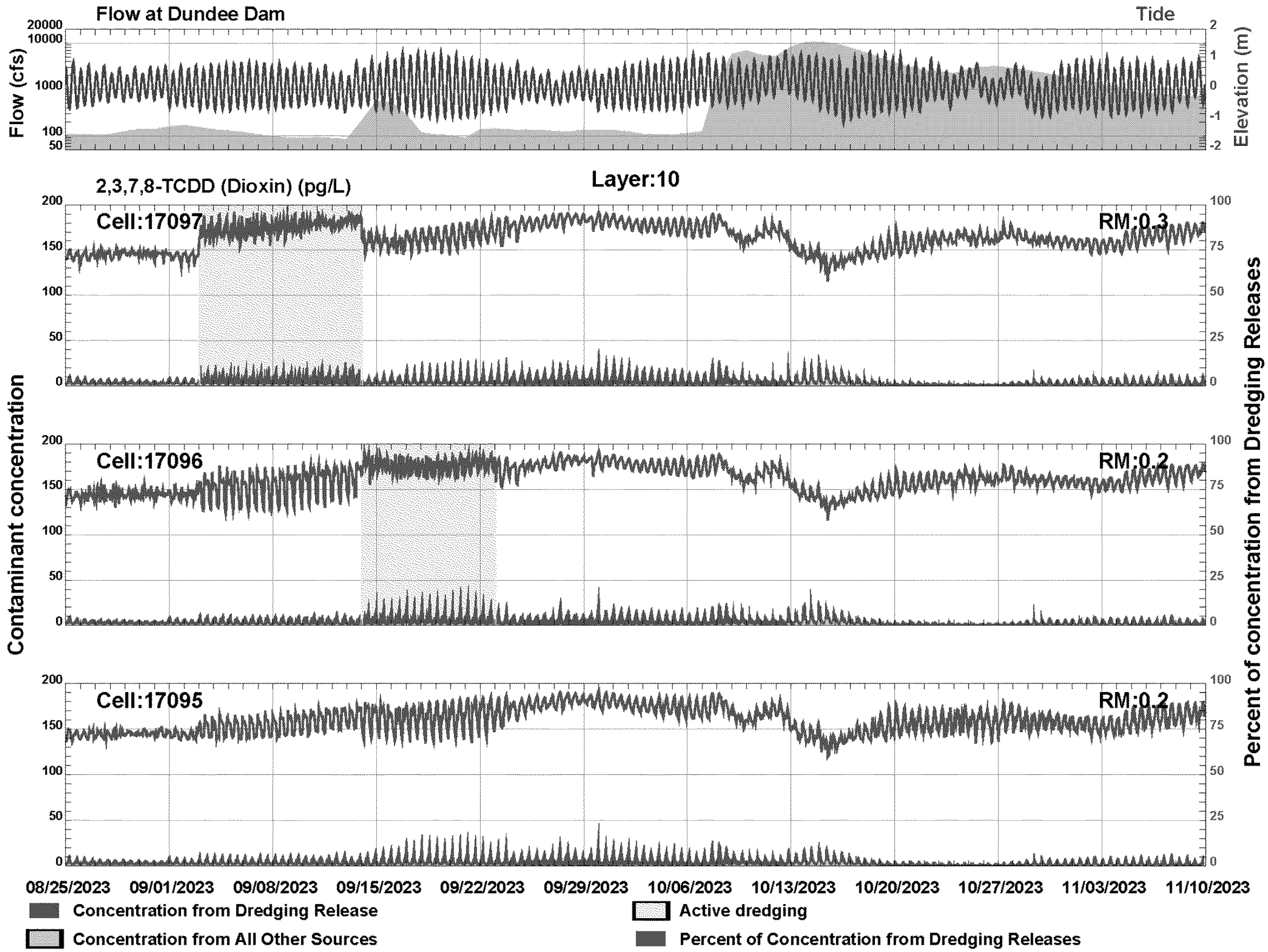
Percentage of 2,3,7,8-TCDD from dredging releases near RM 2.0 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 17 2016



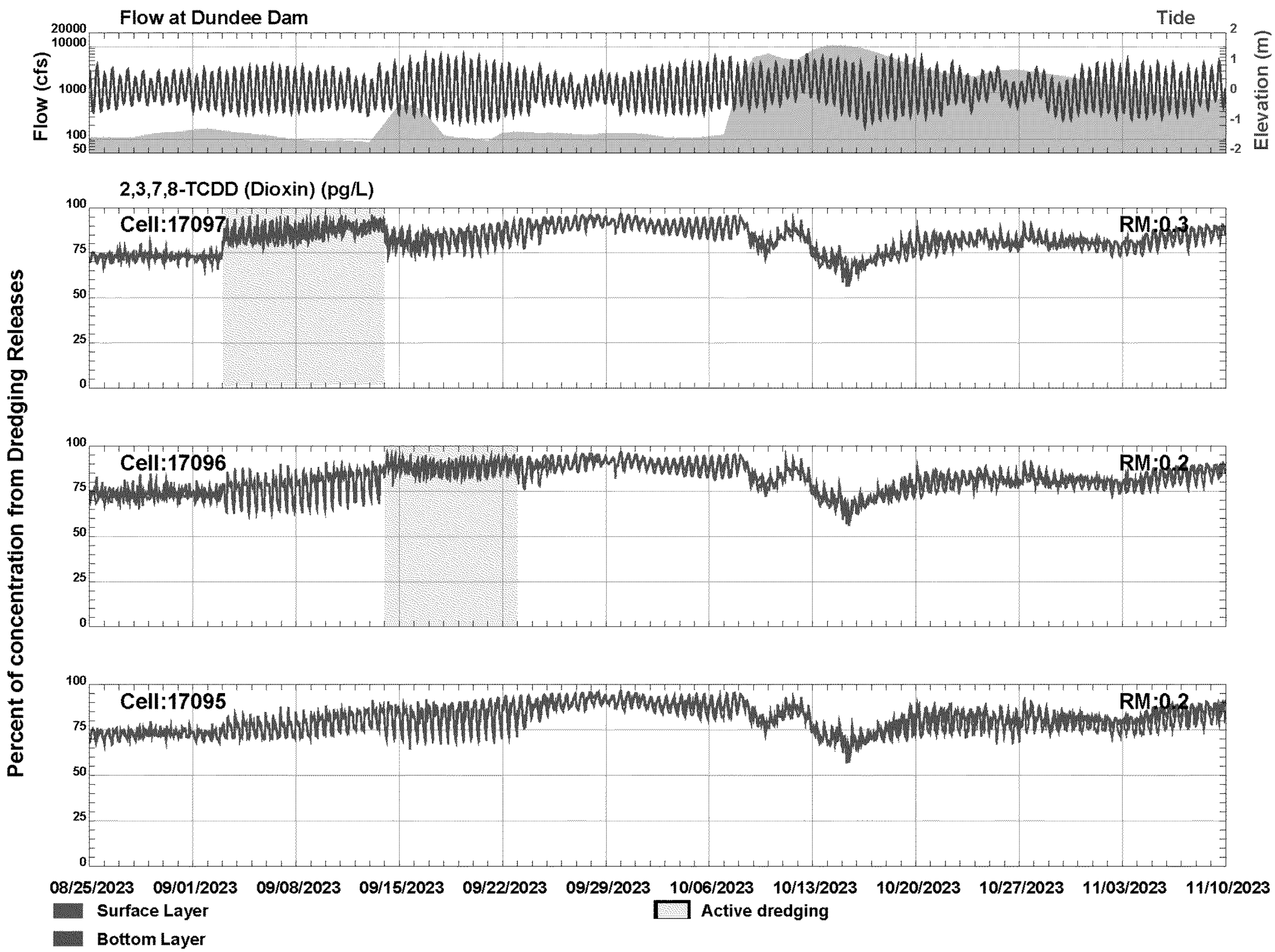
Comparison of 2,3,7,8-TCDD concentrations from Selected Remedy and No Action near RM 0.2 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 18
	2016



2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 0.2 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 19 2016



2,3,7,8-TCDD concentrations from dredging releasesand other sources, and percentage of 2,3,7,8-TCDD from dredging releases near RM 0.2 bottom layer (Assumption: resuspension loss is 3% of dredged mass)	Figure 20
Lower 8.3 Miles of the Lower Passaic River	2016

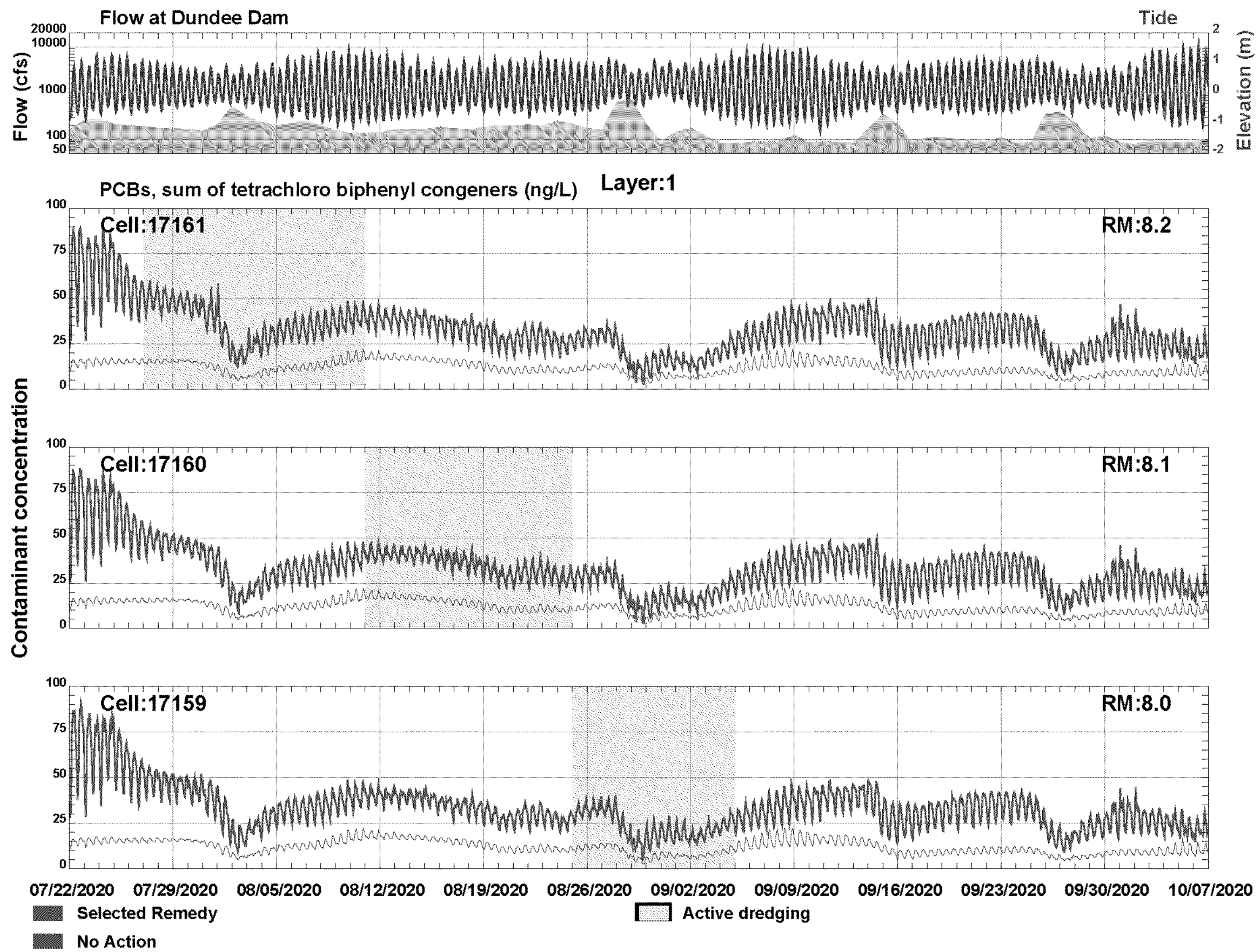


Percentage of 2,3,7,8-TCDD from dredging releases near RM 0.2 (Assumption: resuspension loss is 3% of dredged mass)

Lower 8.3 Miles of the Lower Passaic River

Figure 21

2016

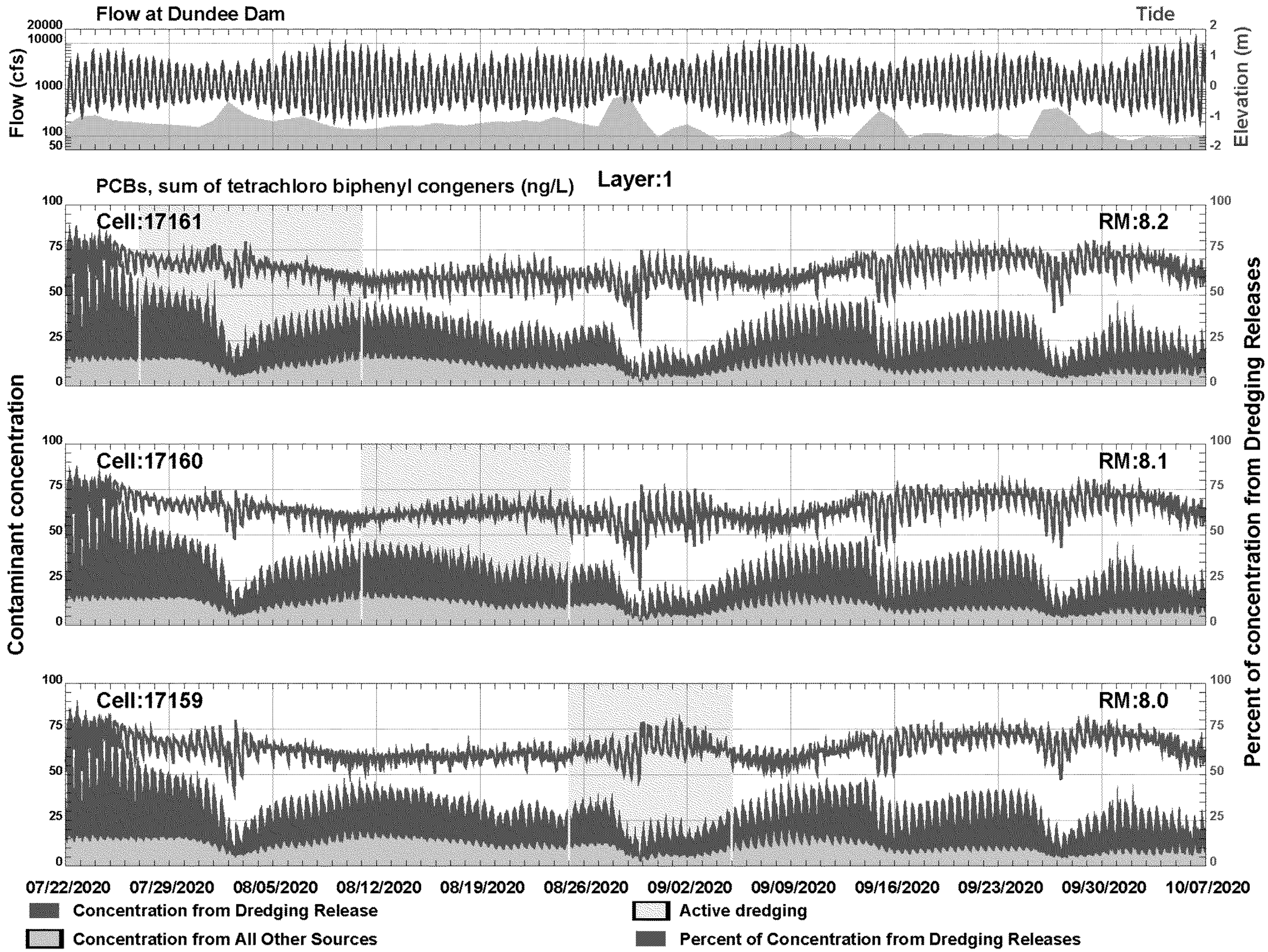


Comparison of Tetra PCB concentrations from Selected Remedy and No Action near RM 8.1 surface layer
(Assumption: resuspension loss is 3% of dredged mass)

Lower 8.3 Miles of the Lower Passaic River

Figure 22

2016

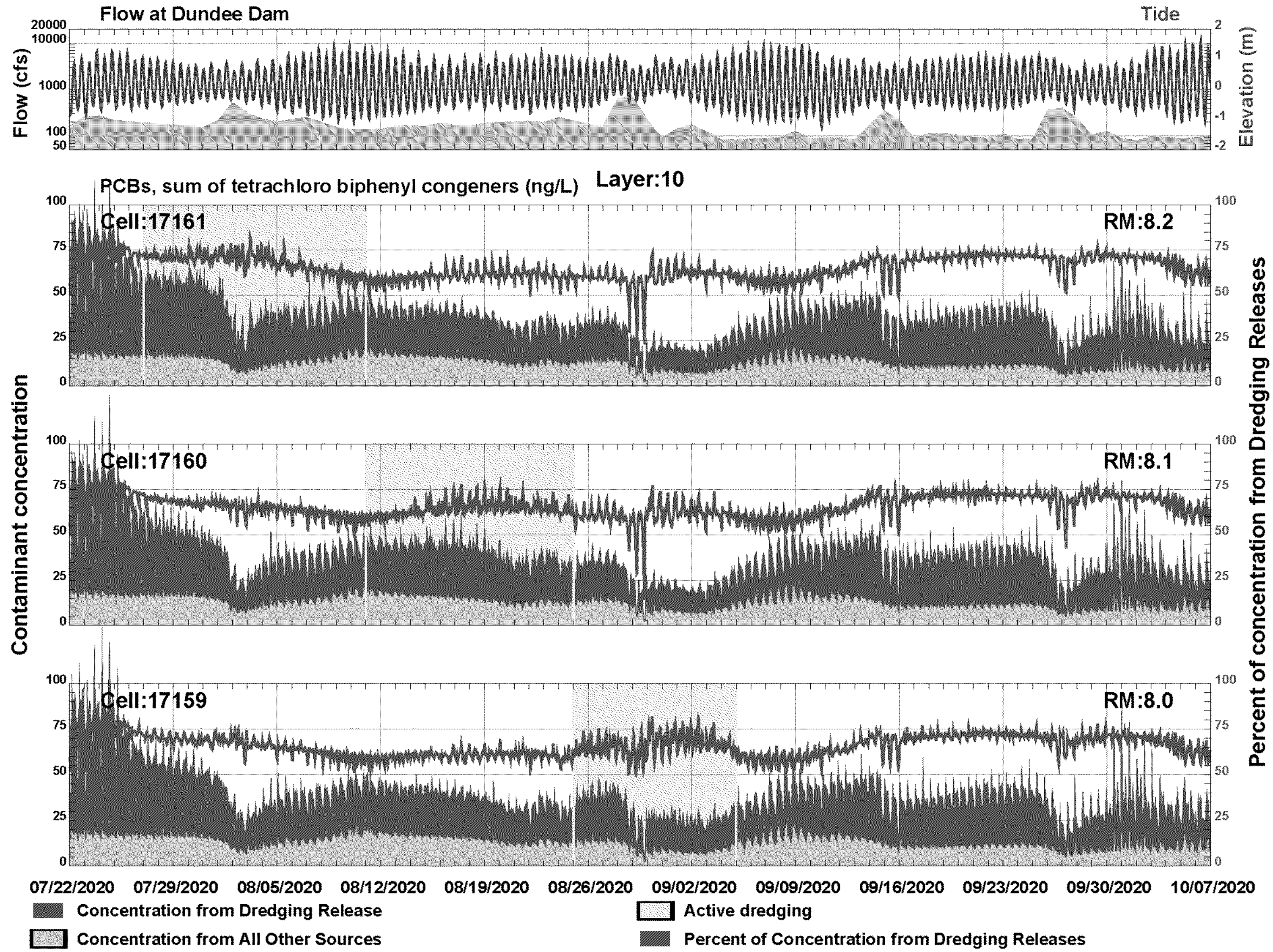


Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 8.1 bottom layer (Assumption: resuspension loss is 3% of dredged mass)

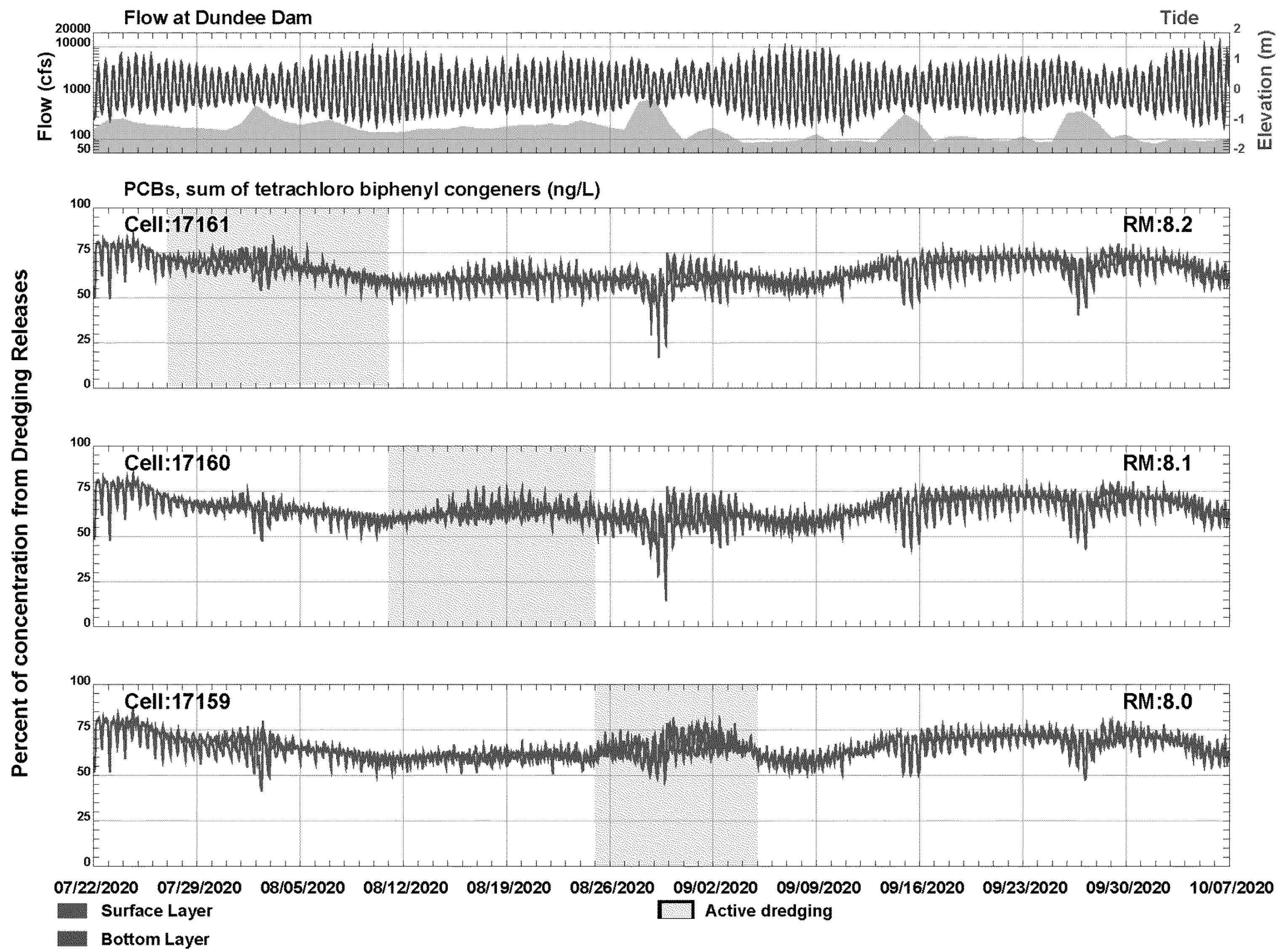
Lower 8.3 Miles of the Lower Passaic River

Figure 23

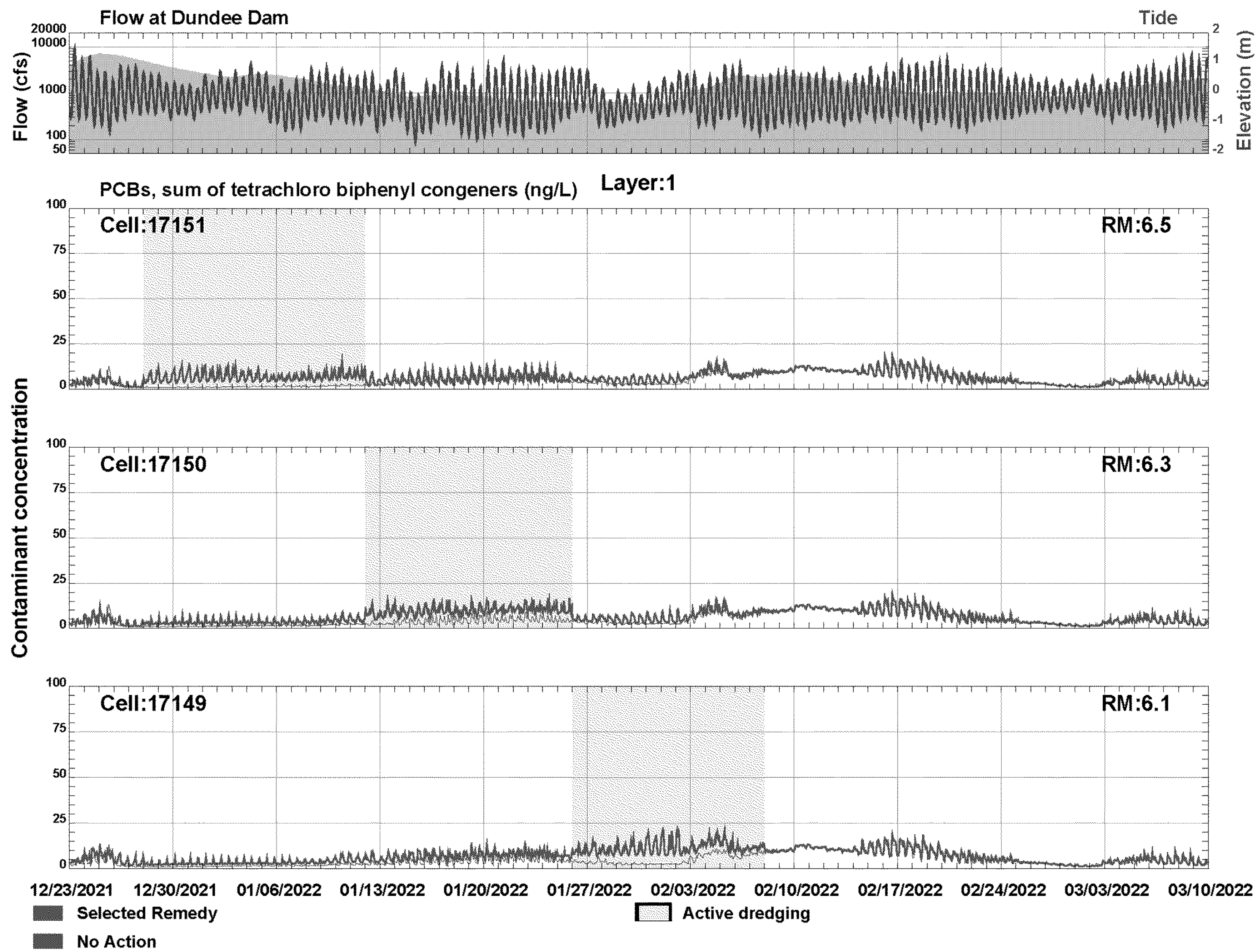
2016



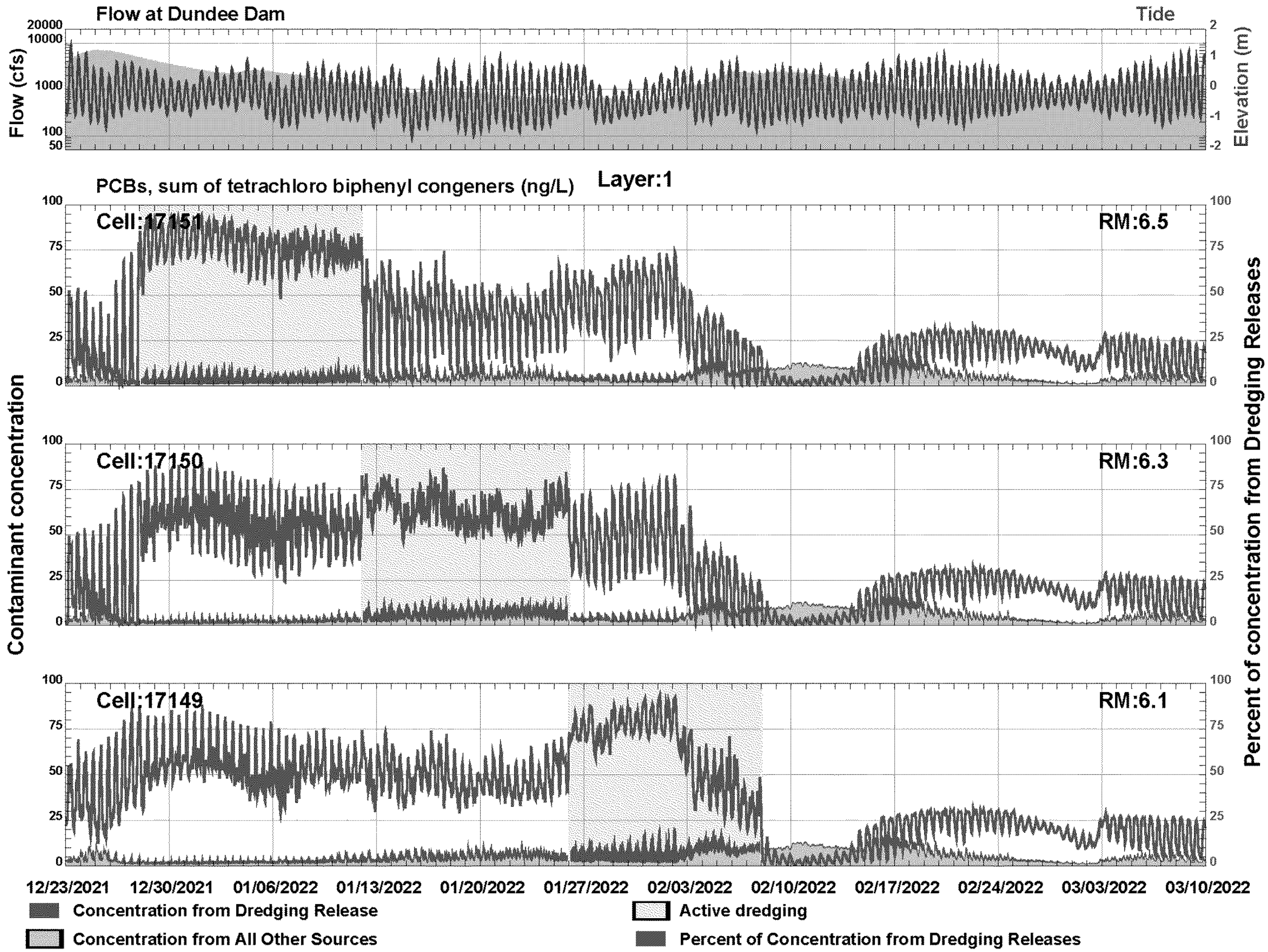
Percentage of Tetra PCB from dredging releases nearRM 8.1 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 24 2016



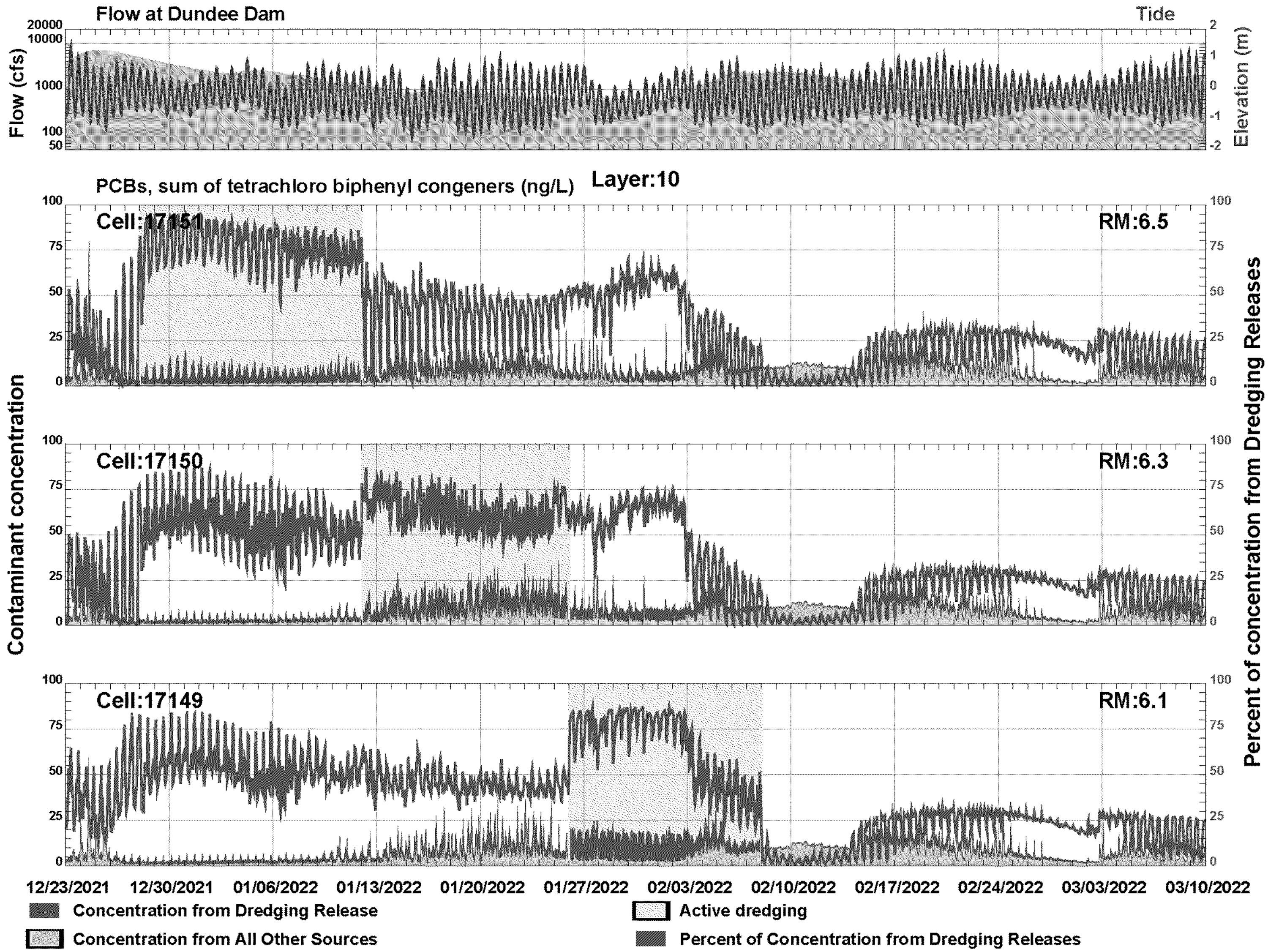
Percentage of Tetra PCB from dredging releases nearRM 8.1 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 25 2016



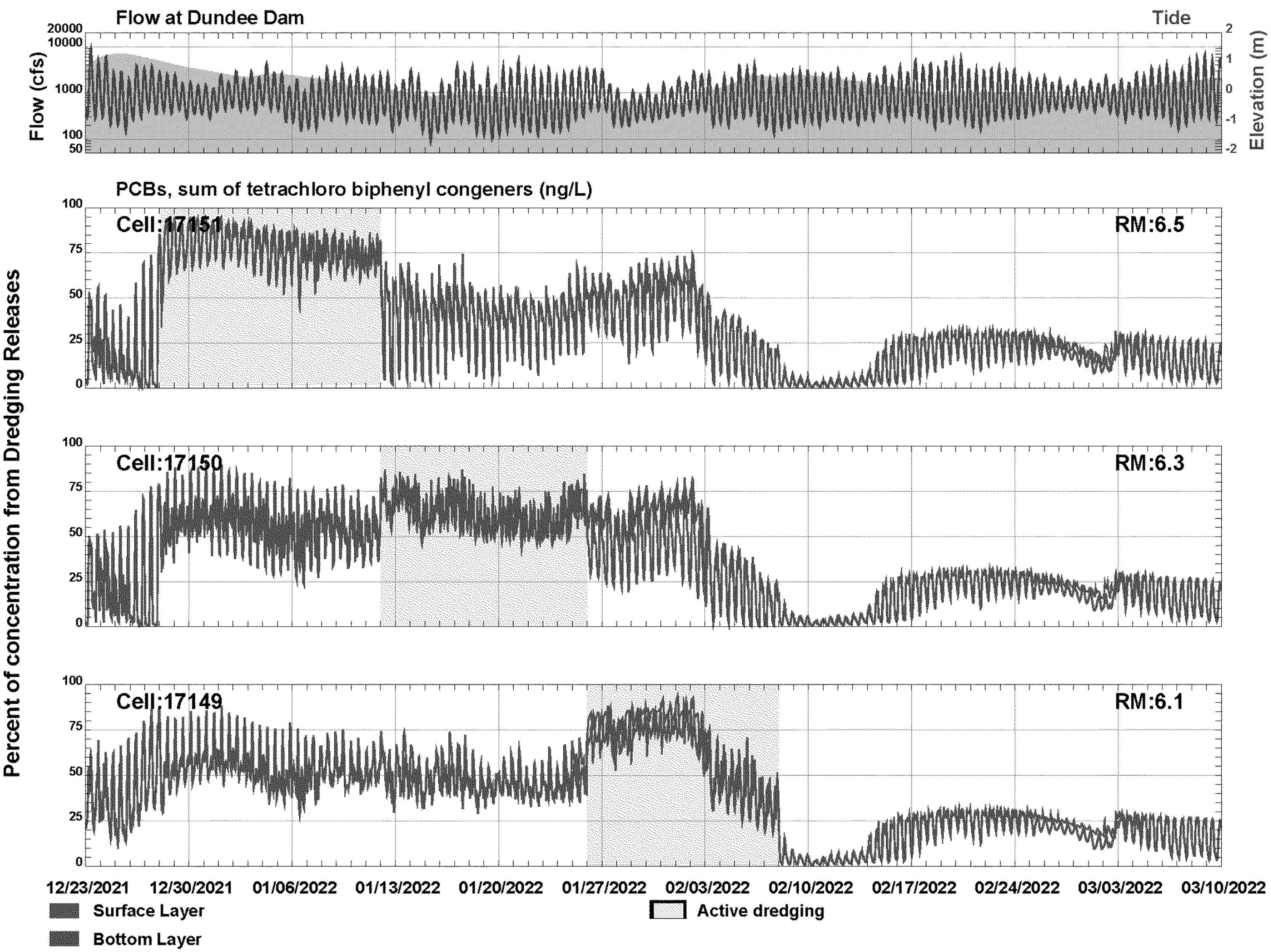
Comparison of Tetra PCB concentrations from Selected Remedy and No Action near RM 6.3 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 26
	2016



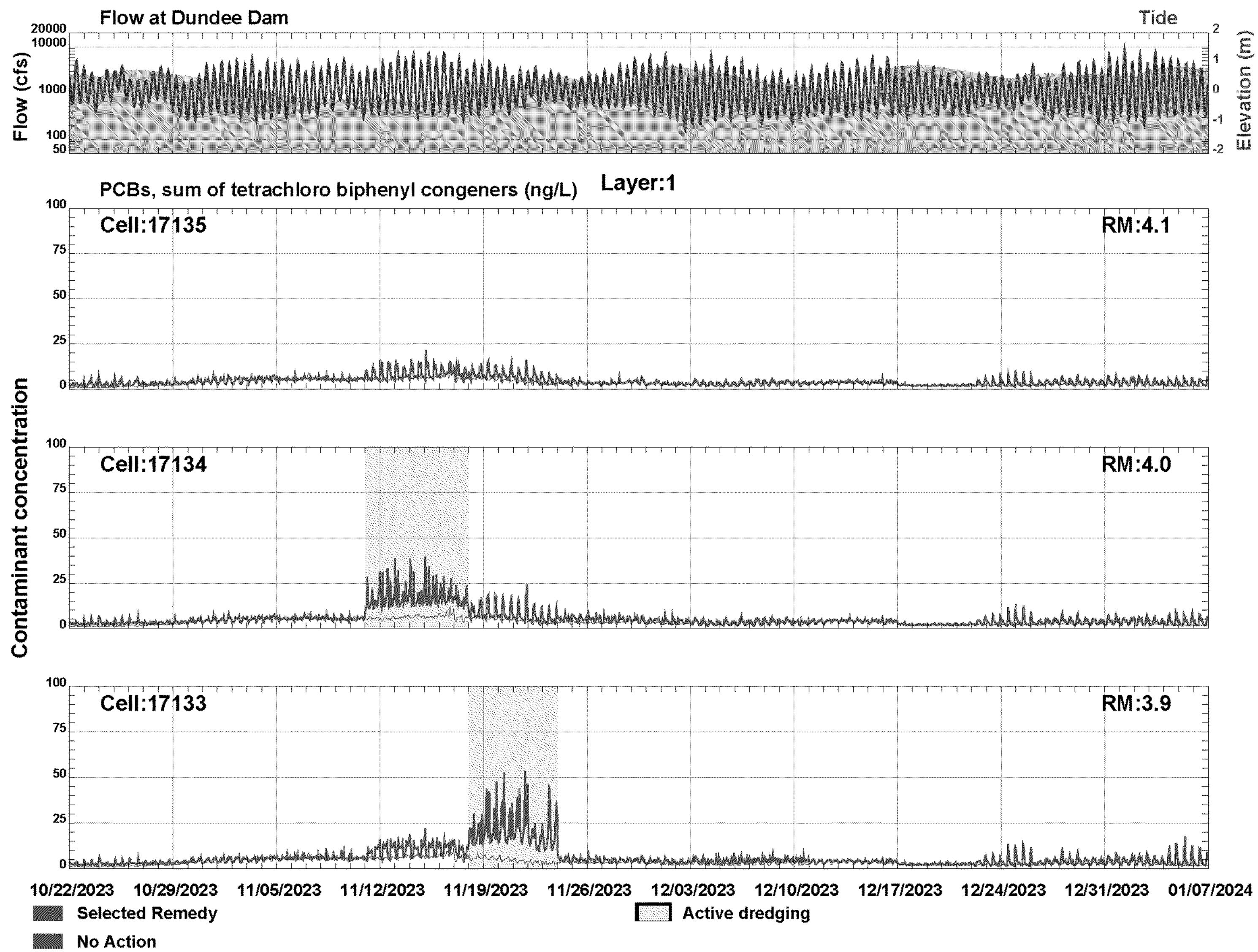
Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 6.3 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 27 2016



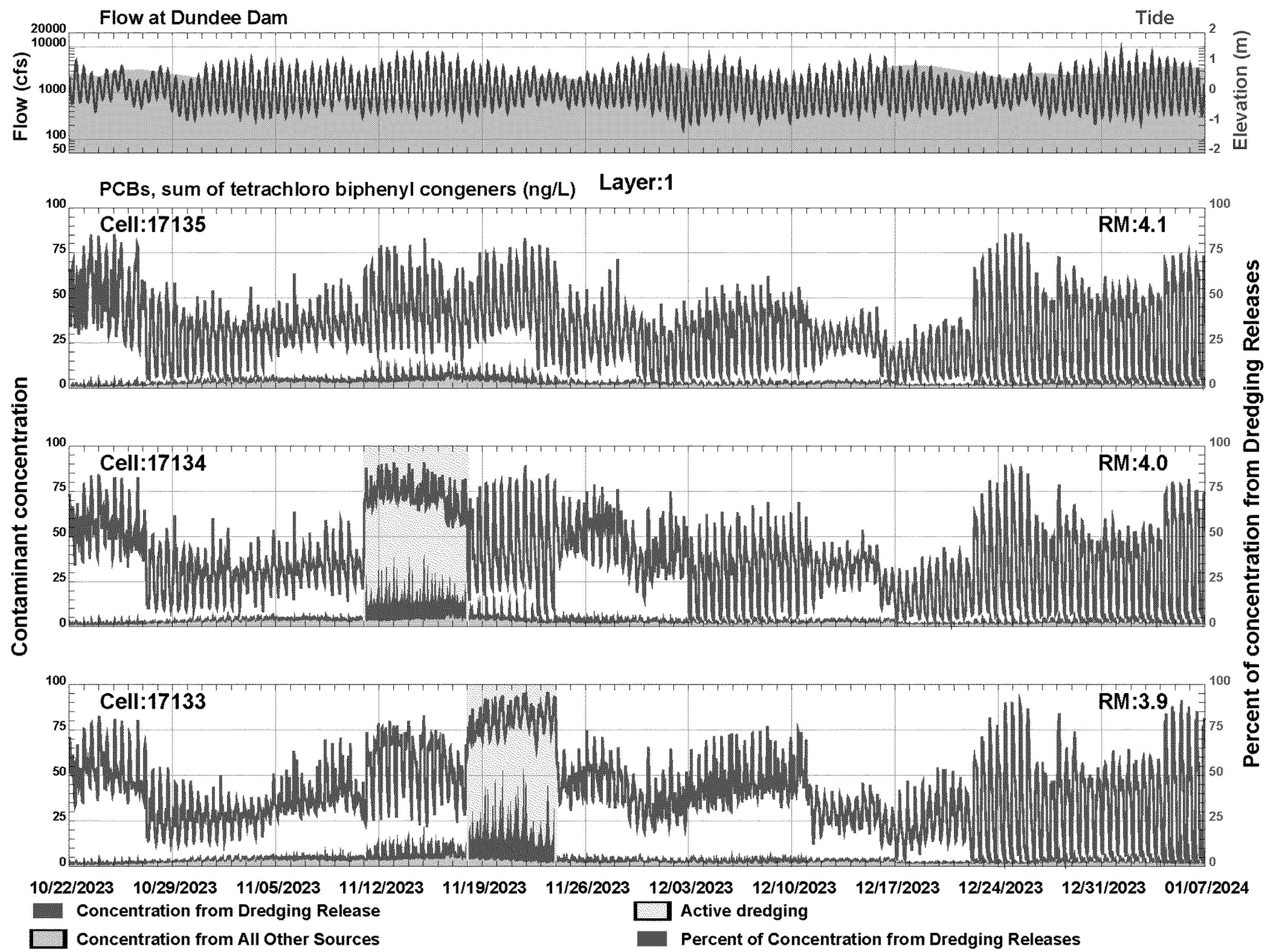
Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 6.3 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 28 2016



Percentage of Tetra PCB from dredging releases nearRM 6.3 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 29 2016



Comparison of Tetra PCB concentrations from Selected Remedy and No Action near RM 4.0 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 30 2016

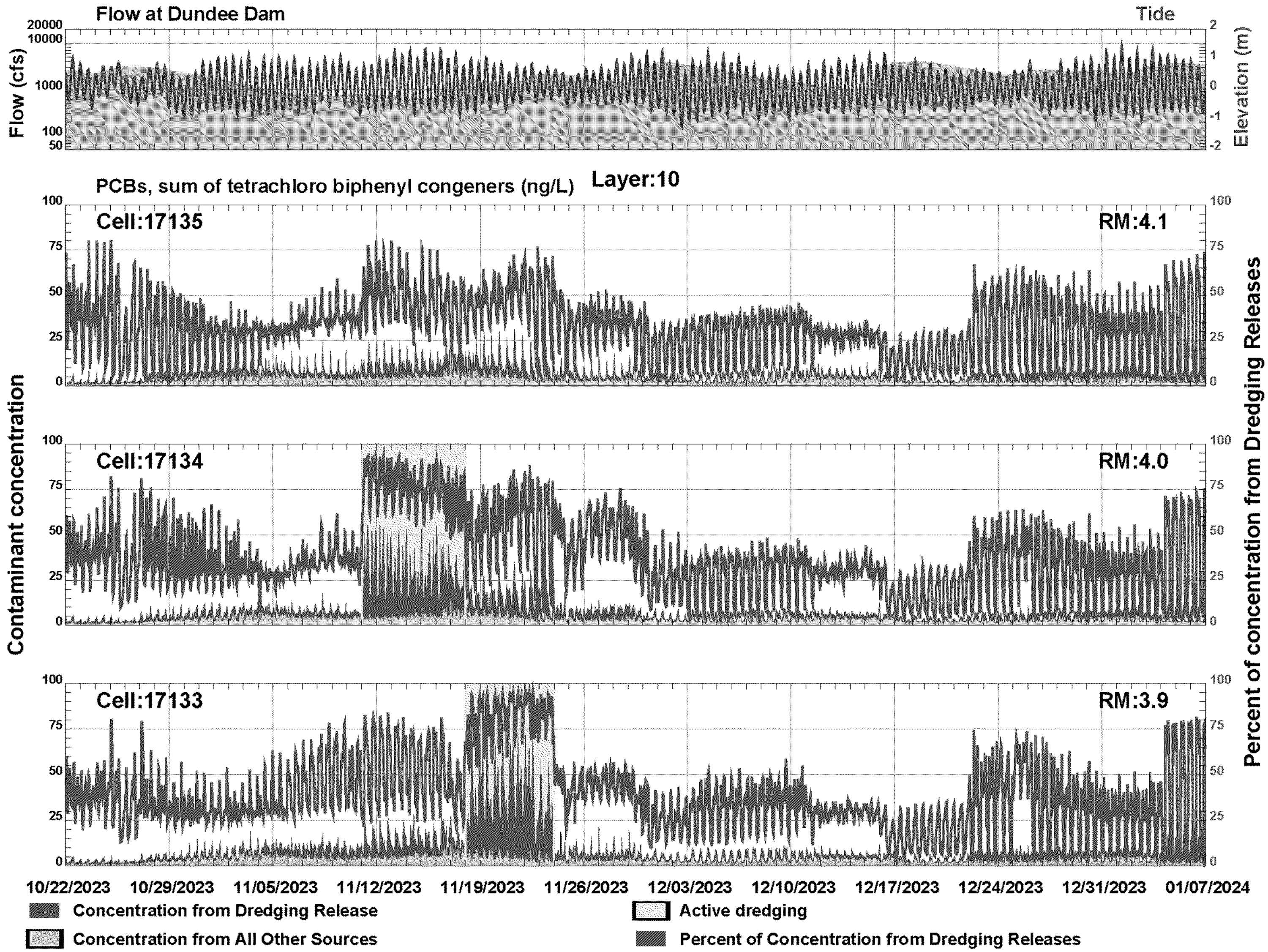


Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 4.0 surface layer (Assumption: resuspension loss is 3% of dredged mass)

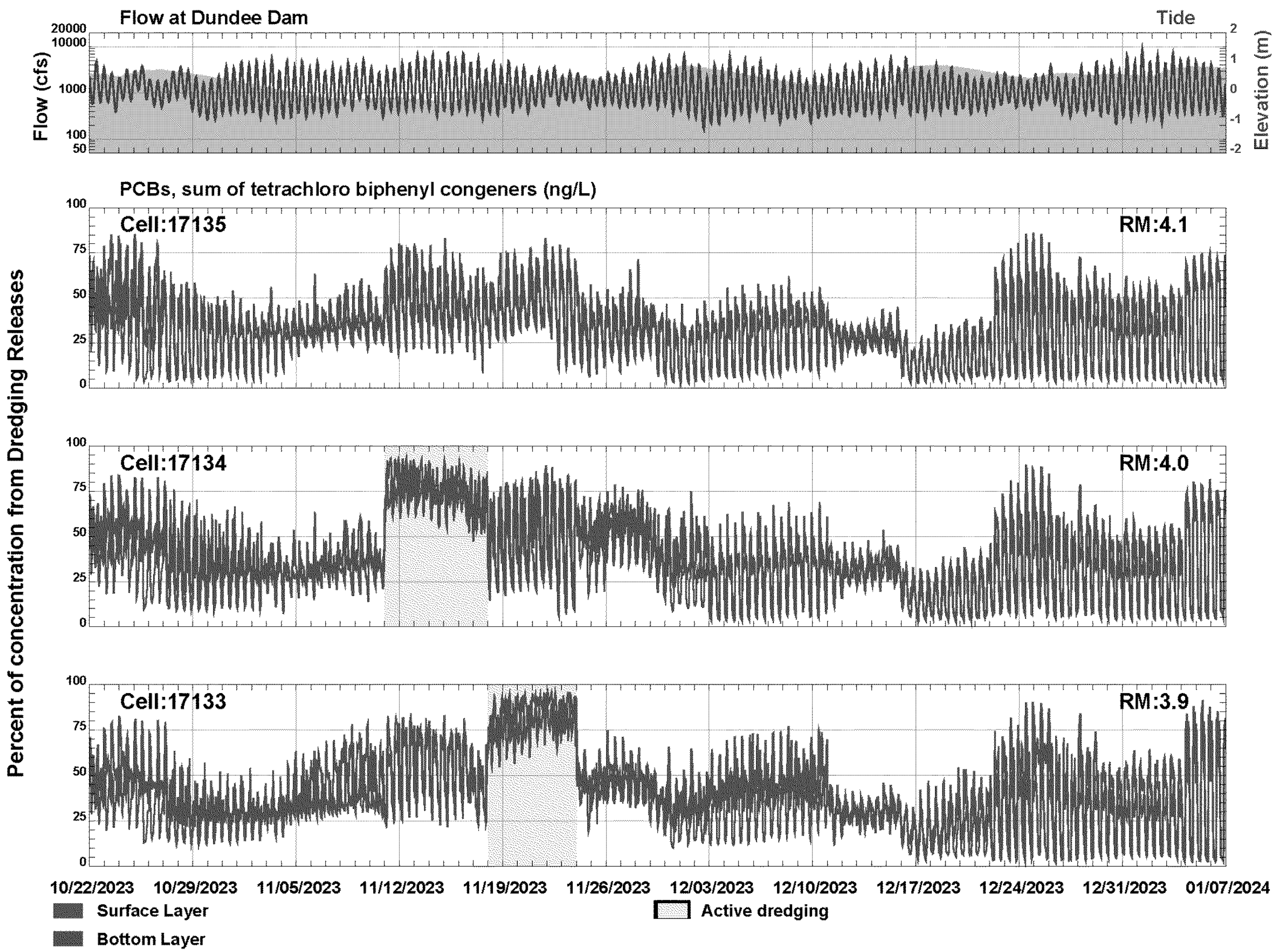
Lower 8.3 Miles of the Lower Passaic River

Figure 31

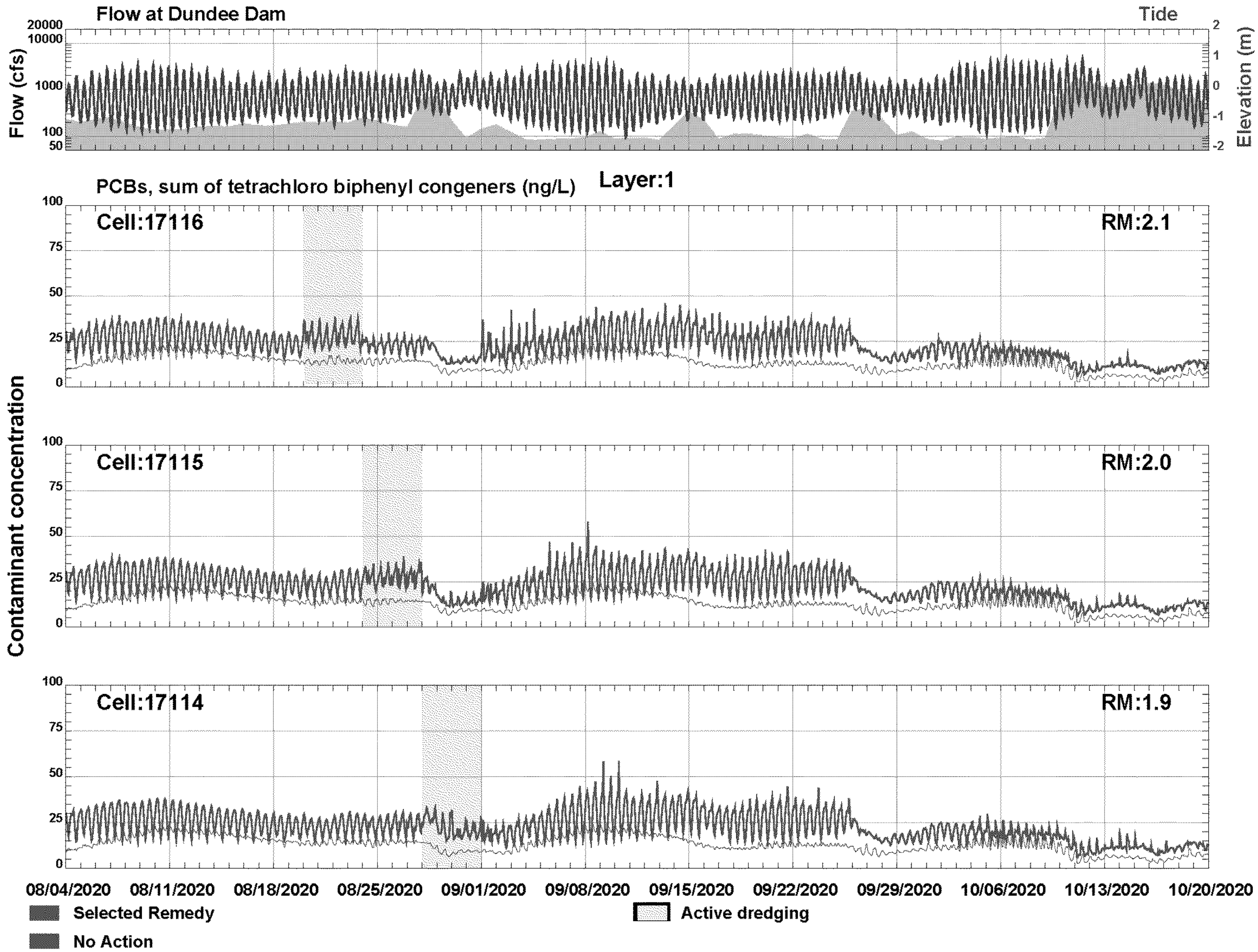
2016



Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 4.0 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 32 2016



Percentage of Tetra PCB from dredging releases nearRM 4.0 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 33 2016

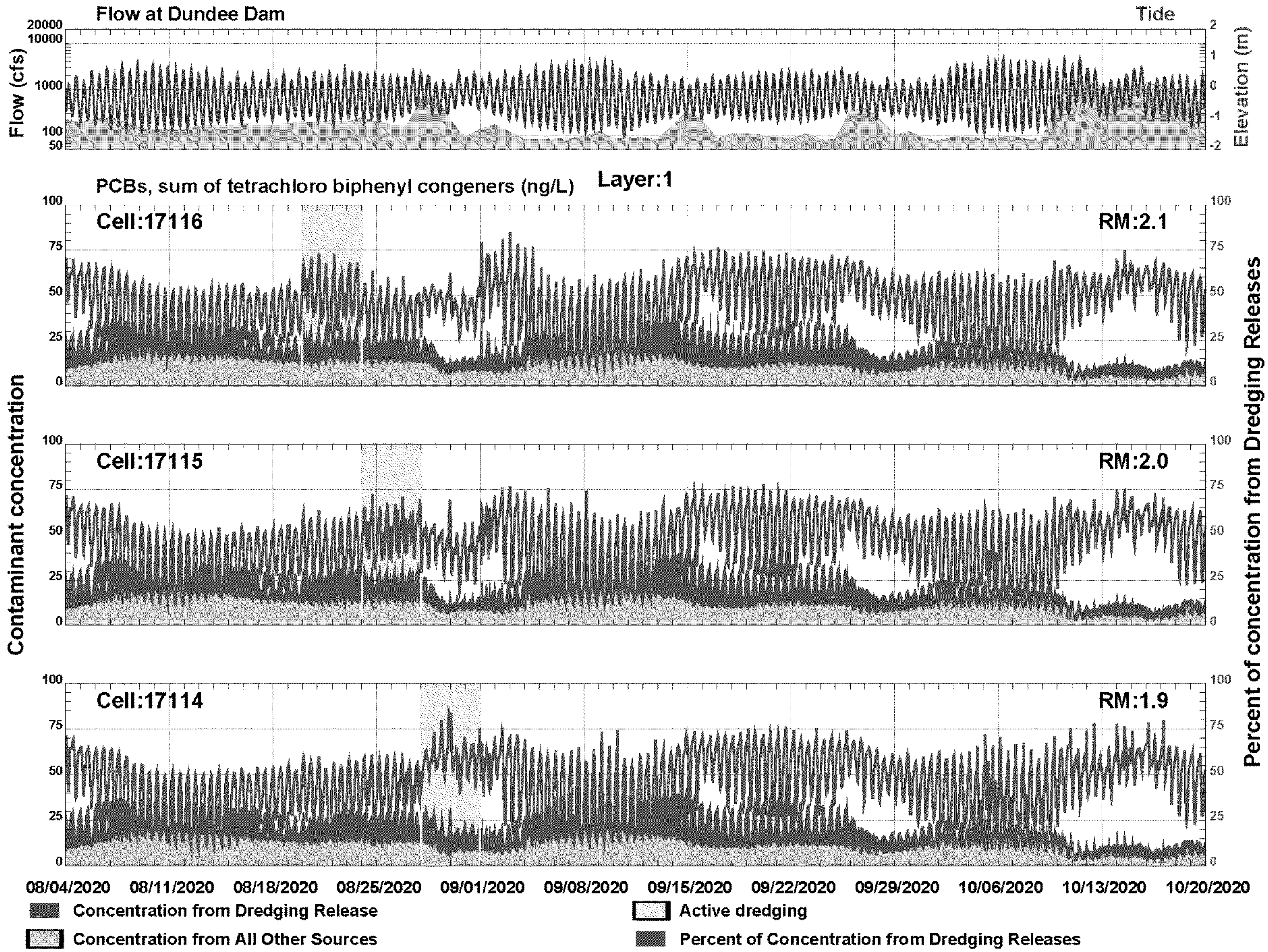


Comparison of Tetra PCB concentrations from Selected Remedy and No Action near RM 2.0 surface layer (Assumption: resuspension loss is 3% of dredged mass)

Lower 8.3 Miles of the Lower Passaic River

Figure 34

2016

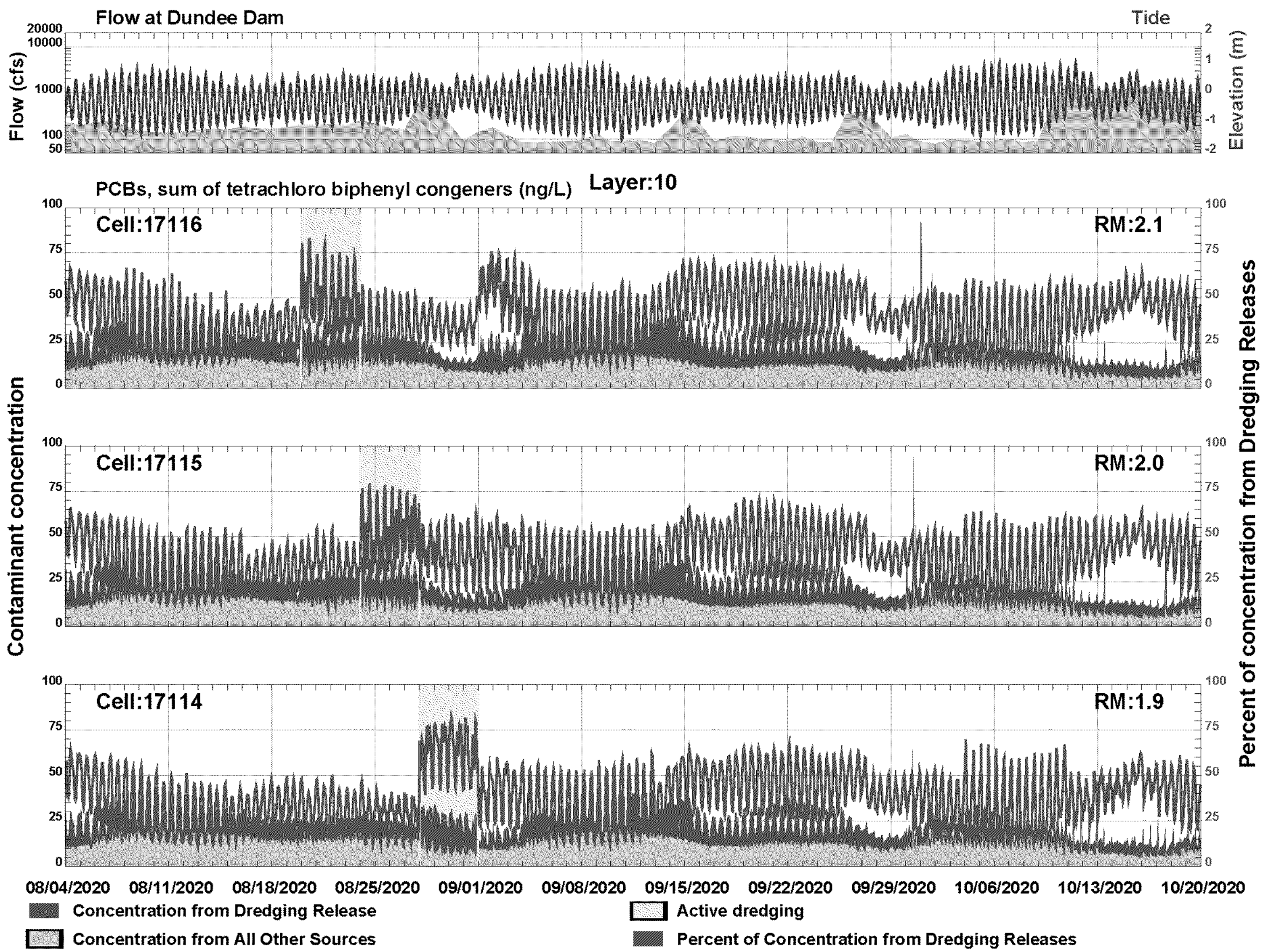


Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 2.0 surface layer (Assumption: resuspension loss is 3% of dredged mass)

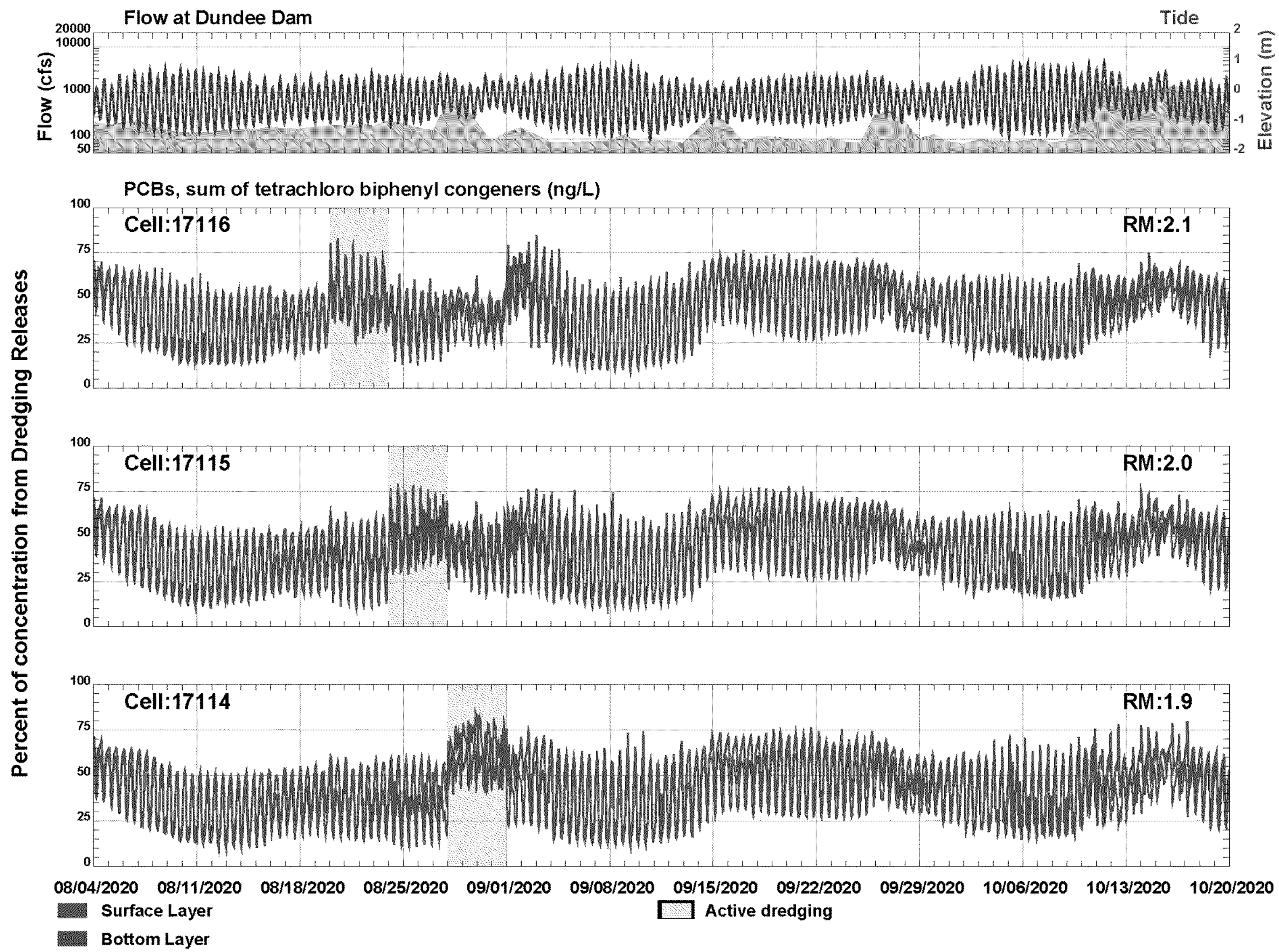
Lower 8.3 Miles of the Lower Passaic River

Figure 35

2016



Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 2.0 bottom layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 36 2016

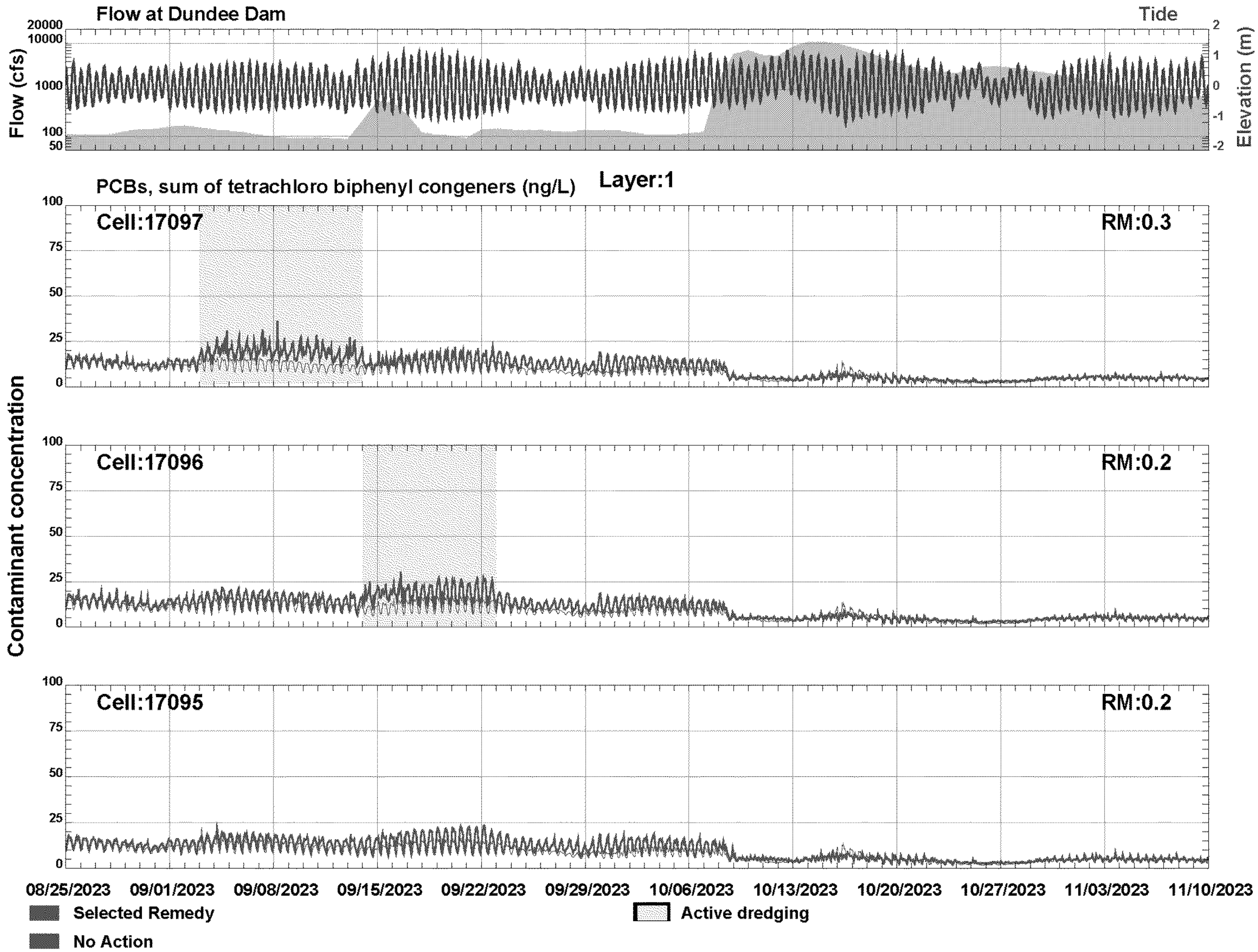


Percentage of Tetra PCB from dredging releases nearRM 2.0 (Assumption: resuspension loss is 3% of dredged mass)

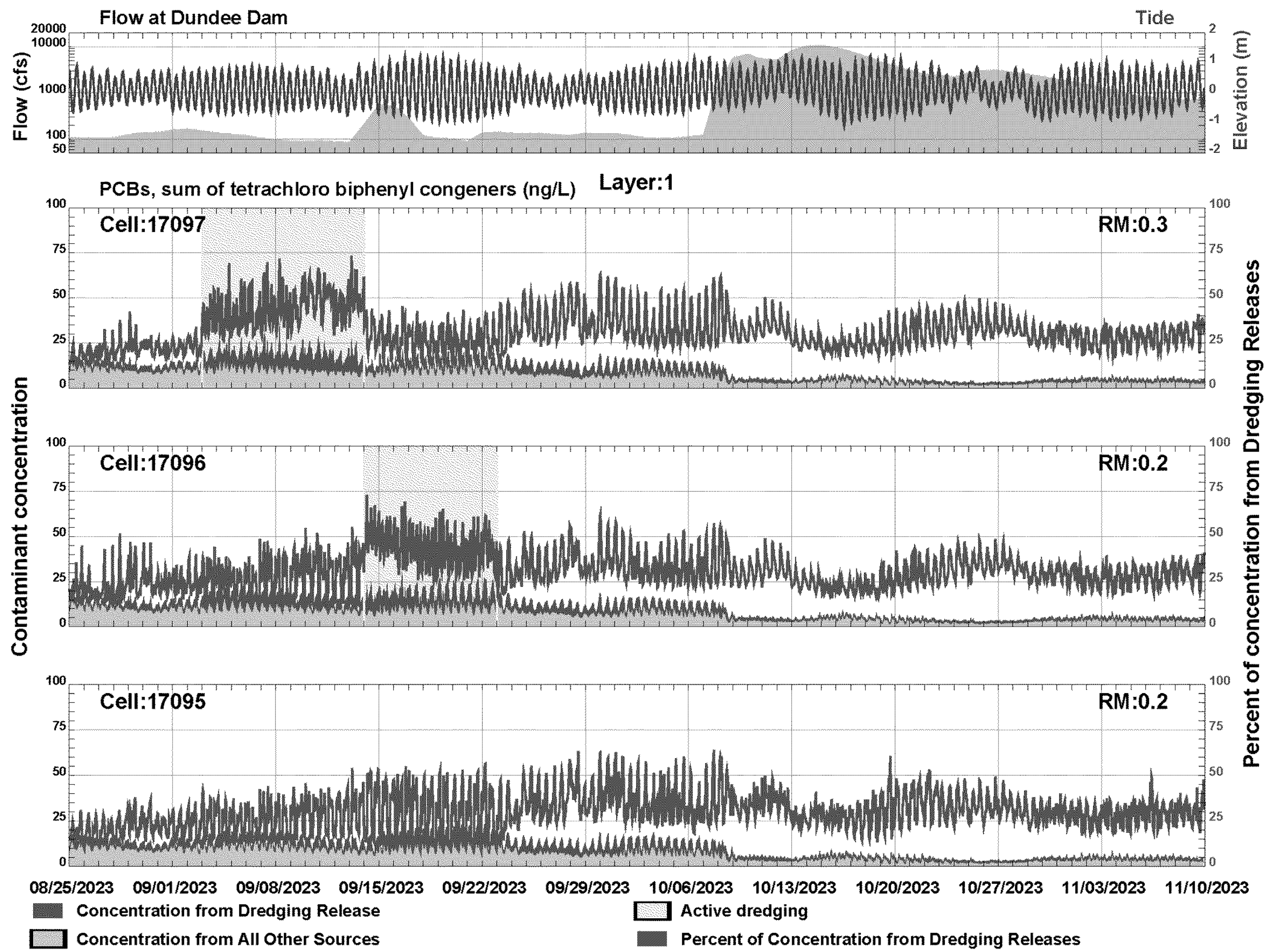
Lower 8.3 Miles of the Lower Passaic River

Figure 37

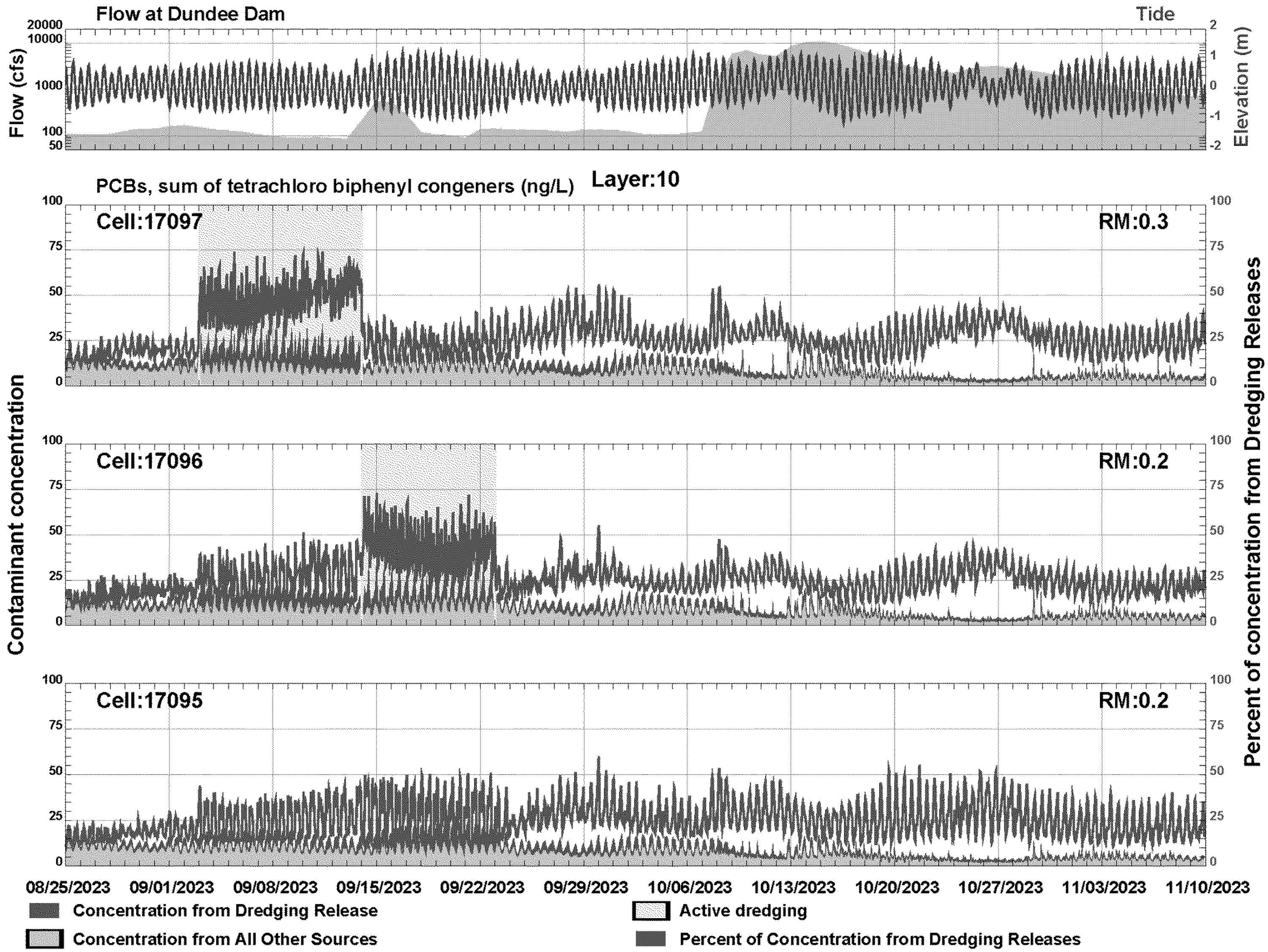
2016



Comparison of Tetra PCB concentrations from Selected Remedy and No Action near RM 0.2 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 38
	2016



Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 0.2 surface layer (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 39 2016

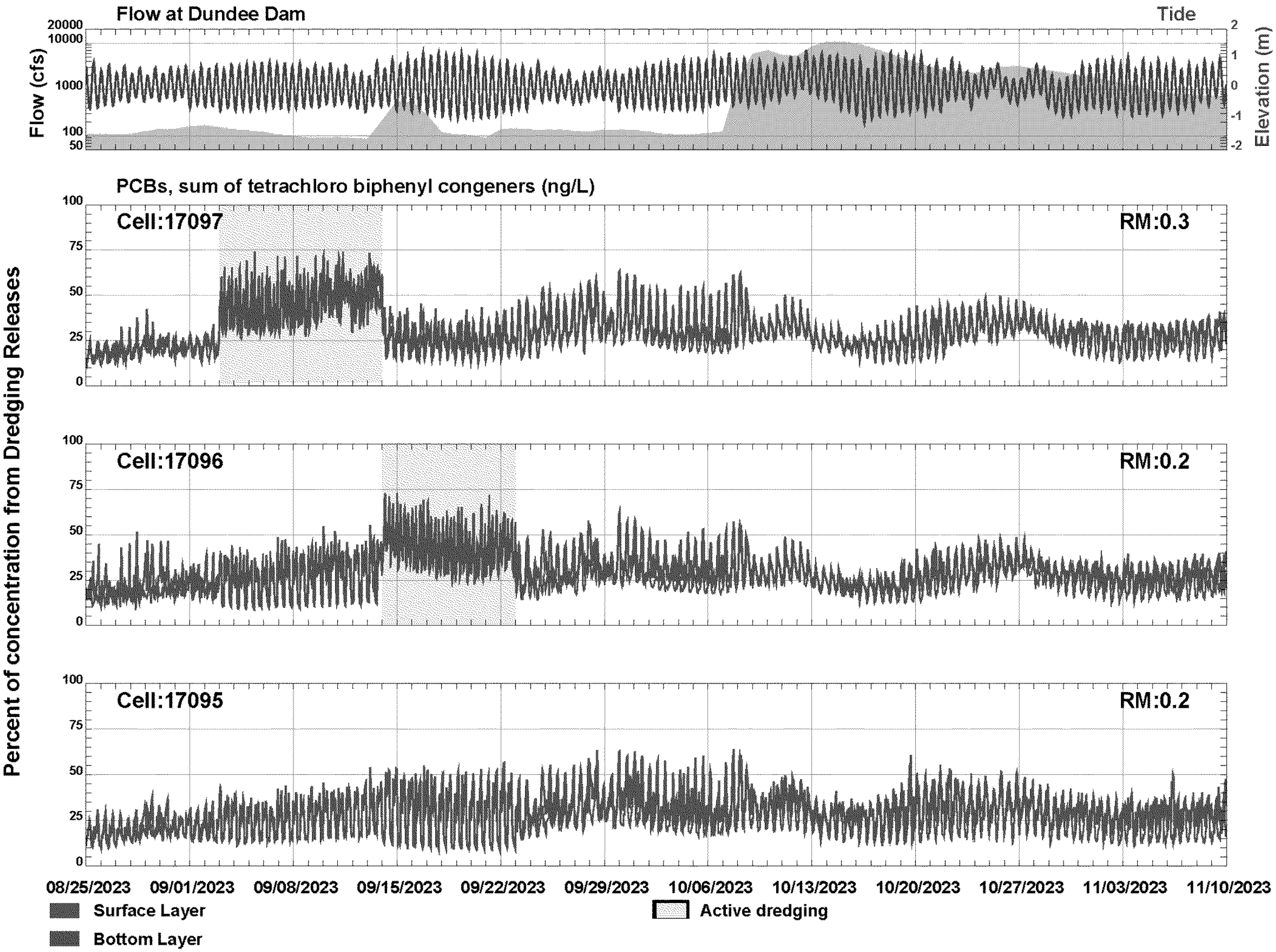


Tetra PCB concentrations from dredging releases andother sources, and percentage of Tetra PCB from dredging releases near RM 0.2 bottom layer (Assumption: resuspension loss is 3% of dredged mass)

Lower 8.3 Miles of the Lower Passaic River

Figure 40

2016



Percentage of Tetra PCB from dredging releases nearRM 0.2 (Assumption: resuspension loss is 3% of dredged mass) *Lower 8.3 Miles of the Lower Passaic River*	Figure 41 2016